

Biomechanical and Clinical Outcomes of a Novel Hallux Valgus Sock: A Clinical Study II

E. Arvanitakis*, C. Formosa, A. Gatt, D. Tsirakos

University of Malta, Podiatry Department, Faculty of Health Sciences, Msida MSD 2080, Malta Metropolitan College, Sport Science and Physical Education, Heraklion Campus, Greece.

Abstract

Background: Hallux Valgus (HV) is a common forefoot deformity, which is associated with pain, changed biomechanics, and functional limitations. The conservative management options are poorly defined in practice, but there may be opportunities for novel, low-cost treatment options.

Objective: The aim was to investigate the effect of a novel HV sock on plantar pressure distribution in people with HV compared to controls and as a stand-alone intervention.

Methods: A prospective, randomized controlled, pre-post experimental design was used and was undertaken with 100 participants (50 control and 50 experimental). The intervention group wore the HV sock on a daily basis for 6-months, and the control group received their usual podiatry care. Baseline, 3-month, and 6-month plantar pressure distribution measured in both groups were assessed using a pressure mapping system that included regions; hallux, 1st MTPJ, 2-3rd, and 4-5th MTPJs. Statistical analysis was conducted using a mixed model ANOVA, to investigate any differences between groups over time.

Results: The experimental group had statistically significant reductions in plantar pressure for all regions ($P < 0.001$) at 6-months while the control group increased previously established pressures in the forefoot. For example, hallux pressures decreased from 243.13 ± 75 to 185.50 ± 58 gr/cm² (left foot) and 259.80 ± 87 to 189.44 ± 69 gr/cm² (right foot) while the control group increased considerably for all PAL measures.

Conclusions: The novel HV sock reduced pathological loading patterns in the forefoot and re-distributed plantar pressure; representing a new conservative intervention for patients with mild to moderate HV. Large scale, long-term studies need to be completed, to determine the practical effectiveness.

Keywords: Hallux valgus; medical devices; conservative treatment; Hallux Valgus sock

INTRODUCTION

Hallux valgus (HV) is a progressive forefoot deformity characterized by lateral deviation of the great toe at the metatarsophalangeal (MTP) joint. This condition often results in the prominence of the first metatarsal head, with overlapping of the first and second toes (Sarwark, 2010; Kim et al., 2013). Available treatments for HV are either invasive or conservative, with no consensus on the most effective conservative approach (Ying et al., 2021)

As an alternative solution to surgery, an affordable and accessible method is needed for the treatment of Hallux Valgus.

The Hallux Valgus Sock [Figure 1], designed to manage HAV, contains an extra elastane fibre that targets the

abductor hallucis longus muscle. This highly advanced technical fabric features a soft, natural feel that moulds to the foot, with a thickness of just 0.3 mm, making it easy to fit into any shoe. The sock aims to strengthen the abductor hallucis muscle, reduce the Hallux angle, and improve foot function in HAV patients.

This study aims to test the hypothesis that the innovative HAV sock reduces the HAV angle and restores normal foot function in individuals living with Hallux Valgus.

***Corresponding Author:** E. Arvanitakis, Metropolitan College, Sport Science and Physical Education, Heraklion Campus, Greece.

The findings could provide valuable insights into the effects of HAV on foot function, pain relief, and quality of life, offering a viable alternative to potentially unwanted surgical interventions.

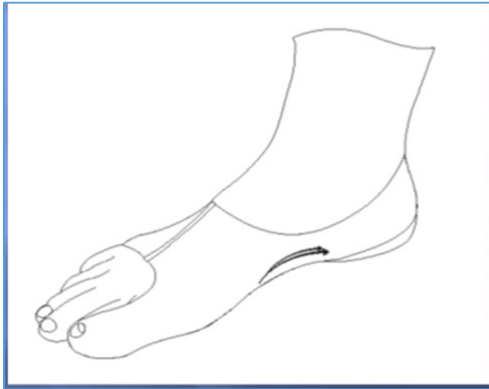


Figure1. *Hallux valgus sock*

METHODOLOGY

A prospective, controlled study was conducted at a private podiatry clinic in Athens to evaluate the effectiveness of an innovative Hallux Valgus (HAV) sock. One hundred adult participants diagnosed with HAV were recruited, all of whom were capable of walking unaided and had no systemic, musculoskeletal, or neurological conditions. Exclusion criteria included the use of walking aids, history of HAV surgery, amputations, angiopathy, or conditions affecting gait such as neuropathy, Parkinson's disease, or cerebral palsy. Informed consent was obtained from all participants.

Participants were randomly assigned into two groups:

- *Control Group (n = 50):* Received routine HAV therapy administered by podiatrists.
- *Intervention Group (n = 50):* Provided with two pairs of the HAV sock to wear daily for one hour during walking activities.

Assessments were conducted at baseline, 3 months, and 6 months. The evaluation protocol included:

Laboratory tests utilizing foot pressure mapping to investigate plantar pressure distribution during gait with and without the Hallux Valgus sock.

A comprehensive participant assessment sheet was developed to document demographic, biomechanical, and anthropometric data. All participants underwent detailed biomechanical examinations, including:

- *Ankle Range of Motion (ROM):* Assessed using the weight-bearing lunge test, which has demonstrated excellent reliability in individuals with chronic ankle

instability (Shi et al., 2023).

- *Midtarsal and Subtalar Joint Assessments:* Evaluated for mobility and alignment.
- *Jack's Test and Hubscher Maneuver:* Utilized to assess the functional mobility of the first metatarsophalangeal joint (MPJ) and the windlass mechanism (Halstead & Redmond, 2006).
- *First Ray Mobility and Hallux 1st MPJ Examination:* Conducted to determine the flexibility and alignment of the first ray and the hallux.
- *Manchester Scale:* Applied for grading the severity of HAV deformity (Menz et al., 2010).
- *Foot Posture Index (FPI-6):* Employed to assess static foot posture, with established normative values and proven inter-rater reliability (Redmond et al., 2008; Morrison & Ferrari, 2009).

Foot Pressure Mapping

Participants were instructed to walk barefoot with and without the hallux sock at a self-selected speed using the two-step method (Chevalier et al, 2010; van der Leeden et al, 2004; McPoil et al, 1999) over the Sensori medica Mat system (Sensori medica, Italy), where a period of acclimatization was advised to practice placing one foot completely on the mat without targeting. This was followed by recording five trials. Plantar pressure analysis was performed using a pressure mapping platform, where pressure time integral data were obtained. Each foot in every trial was masked and divided into four anatomical landmarks, including the first toe, first metatarsal head, second to fourth metatarsal head and the fifth metatarsal head as per standard protocol. The analyzed plantar pressure results from the five correct trials were averaged and recorded on Microsoft Excel.



Figure2. *Foot Pressure Mapping with the hallux valgus sock*

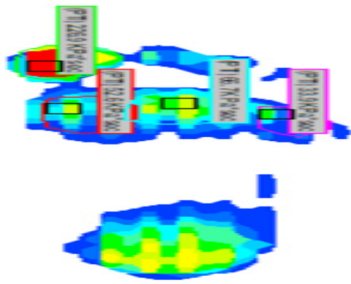


Figure 3. Maximum pressure on anatomical site on the foot

RESULTS

Demographic Data

All 100 participants (99 female, 1 male) (mean 55 years, 72.4 kg and 159 cm) voluntarily took part in the study. The severity of hallux valgus varied from mild to severe hallux valgus. Forty-four participants presented with a grade B hallux valgus on the Manchester Scale, 40 participants presented with a grade C, 15 participants presented with a grade A, and 1 participant presented with a grade D score on the right foot according to the Manchester Scale. Sixty participants had a grade B hallux valgus, 25 grade C, 14 grade A, and 1 grade D score on the left foot according to the Manchester Scale (Garrow et al., 2001).

The Foot Posture Index [FPI] on the right foot was recorded as neutral for all participants and slightly pronated for the left foot respectively. Most of the participants [n= 99] were found to be dorsiflexed on ankle range of motion on both feet and only one participant had sight limitation.

The range of motion of the midtarsal joint for most of participants was normal (92 participants for both feet) and 40 participants were hypermobile on both feet. The

Table 1. Descriptive statistics for the Hallux pressure of the left and right foot for the control and experimental groups over time.

TREATMENT TIME	LEFT FOOT		RIGHT FOOT	
	CONTROL	EXPERIMENTAL	CONTROL	EXPERIMENTAL
HAV_Pressure_0m	244.41 ± 82	243.13 ± 75	275.33 ± 71	259.80 ± 87
HAV_Pressure_3m	272.83 ± 94	208.55 ± 62	206.77 ± 82	226.04 ± 85
HAV_Pressure_6m	298.30 ± 99	185.50 ± 58	340.05 ± 89	189.44 ± 69

Based on the results presented in Table 1 and Figure 1, it is evident that Hallux pressure was reduced with the use of the sock over time in both feet (left and right) for the experimental group, while it was increased in both feet for the control group. This increase of the hallux valgus pressure at the control group was noted from 244.41 ±

range of motion of the subtalar joint was normal for the 98 participants for both feet and two participants were hypermobile on both feet. Jack test was normal for the 98 participants and restricted for only two participants for both feet.

The Hubscher Manoeuvre test showed that sixty participants were normal, forty restricted on the right foot, seventy participants were normal and thirty restricted on the left foot. The range of motion of the 1st MPJ was 80 participants normal, 20 limited on the right foot, 98 normal and two limited on the left foot. Finally, the range of motion of the 1st ray was normal for 80 participants on the right foot and 20 participants were limited on the left foot.

Statistical Analysis

A mixed model of analysis of variance (ANOVA) test was employed to analyze the distribution of data for peak plantar pressure under the hallux, the 1st MPJ, 2-3rd MPJ, 4-5th MPJ, before (pre-) and after (post-) use of the Hallux Valgus Sock during the three different periods: 0, 3 months and 6 months. In all cases, the requirements related to the mixed ANOVA test were examined and met for the investigated data.

Pressure at Hallux Valgus of the control vs experimental groups

Table 1 and Figure 4 below present the descriptive statistics of the mean values and standard deviation for the Hallux pressure measurements over time at 0 months, 3 months and 6 months of treatment for the control and experimental groups in the left and right foot. It is important to clarify that the control groups did not use the innovative sock, while the experimental groups used the sock, with specific guidelines for six six-month periods

82 to 298.30 ± 99 gr/cm² over time of treatment for the left foot and from 275.33 ± 71 to 340.05 ± 89 gr/cm² for the right foot. These results indicated that not using the innovative sock affects the pressure at the hallux valgus area. Additionally, it was noted that pressure at the hallux in the experimental group was reduced in both the left and

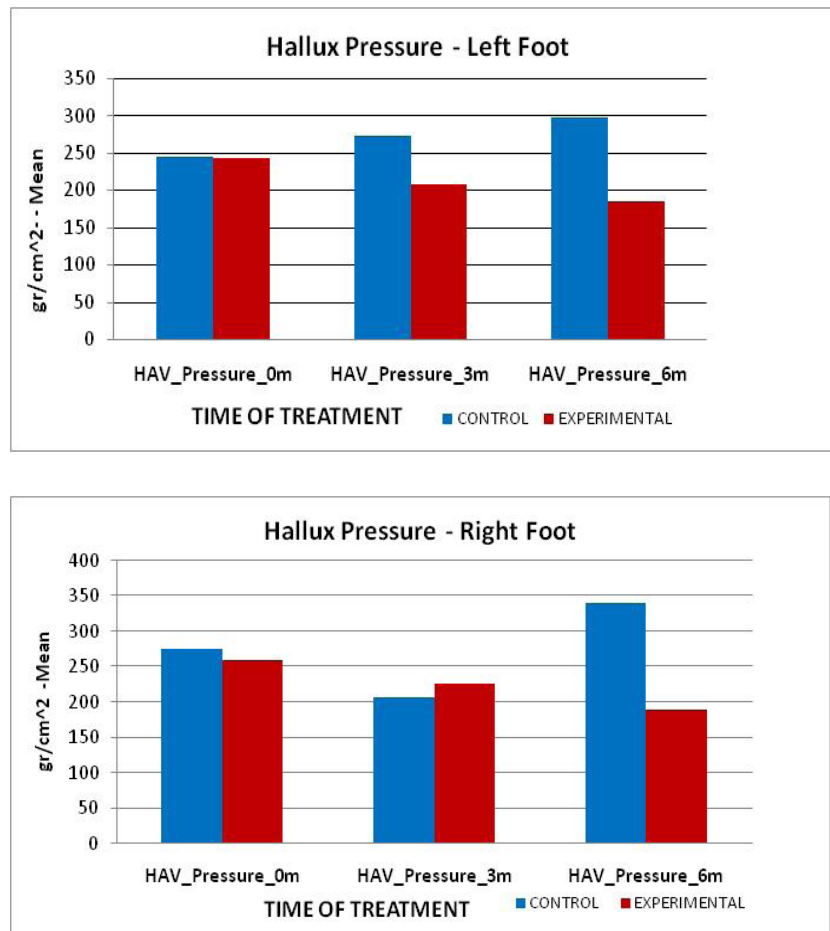


Figure4. Histograms of the Hallux pressure of the left and right foot for the control and experimental groups over time.

right foot while using the sock. Specifically, the pressure at the hallux valgus reduced from 243.13 ± 75 to 185.50 ± 58 gr/cm² over time of treatment for the left foot and from 259.80 ± 87 to 189.44 ± 69 gr/cm² for the right foot. These results indicated that using the innovative sock positively affects the maximum pressure at the hallux valgus area in

both feet.

Pressure at 1stmpj of the Control Vs Experimental Groups

Table 2 and Figure 5 below present the descriptive statistics of the mean values and standard deviation for

Table2. Descriptive statistics for the pressure at 1st MPJ of the left and right foot for the control and experimental groups over time.

TREATMENT TIME	LEFT FOOT		RIGHT FOOT	
	CONTROL	EXPERIMENTAL	CONTROL	EXPERIMENTAL
1STMPJ_Pressure_0m	173.08 ± 54	156.73 ± 46	197.08 ± 73	182.61 ± 65
1STMPJ_Pressure_3m	201.13 ± 65	134.74 ± 41	231.37 ± 80	148.16 ± 52
1STMPJ_Pressure_6m	222.73 ± 67	118.23 ± 40	254.24 ± 46	123.93 ± 46

the pressure measurements for the 1st MPJ over time at 0 months, 3 months and 6 months of treatment for the control and experimental groups in the left and right foot.

Based on the results presented in Table 2 and Figure 5, it can be noted that the pressure at 1STMPJ was reduced over time with the use of the sock in both feet (left and right)

for the experimental group, while it increased in both feet for the control group.

This increase in pressure at the 1st MPJ for the control group was noted from 173.08 ± 54 to 222.73 ± 67 gr/cm² over the treatment period for the left foot, and from 197.08 ± 73 to 254.24 ± 46 gr/cm² for the right foot. These

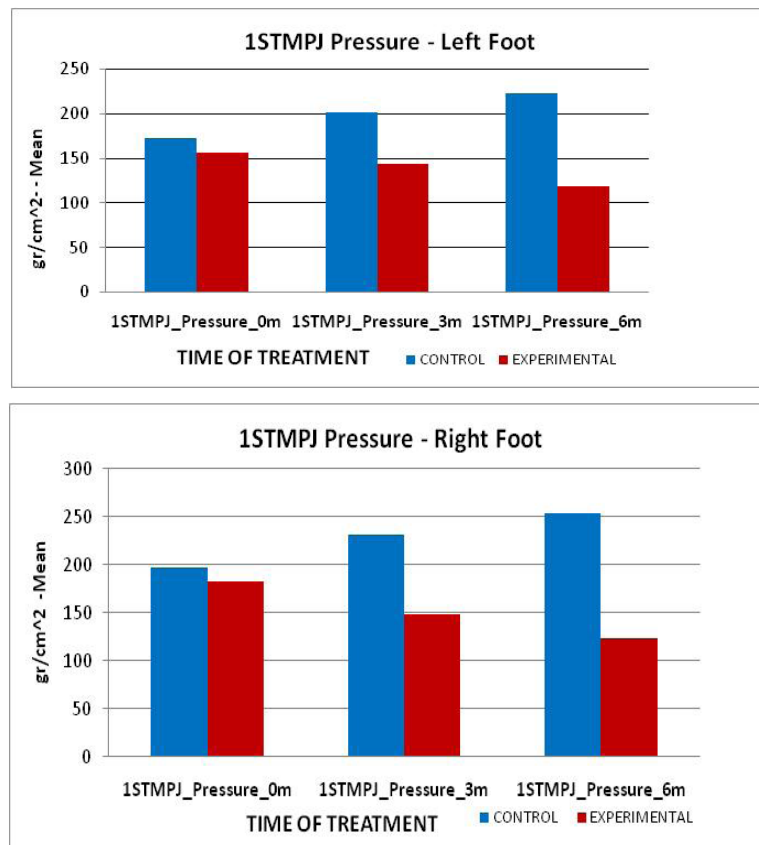


Figure5. Histograms of pressure at the 1st MPJ of the left and right foot for the control and experimental groups overtime.

results indicated that not using the innovative sock affects the pressure at the 1st MPJ area.

Furthermore, it was noted that pressures at the 1st MPJ area for the experimental group were reduced in both the left and right foot, as a result of using the sock. Specifically, the pressure at the 1STMPJ reduced from 156.73 ± 46 to 118.23 ± 40 gr/cm² over time of treatment for the left foot and from 182.61 ± 65 to 123.93 ± 46 gr/cm² for the right foot. These results indicated that using the innovative sock

positively affects the pressures at the 1st MPJ area, in both feet.

Pressure At 2-3rd Mpj of the Control Vs Experimental Groups

Table 3 and Figure 6 below present the descriptive statistics of the mean values and standard deviation for the pressure measurements at 2-3rd MPJ over time at 0 months, 3 months and 6 months of treatment for the control and

Table3. Descriptive statistics for the pressure at the 2nd-3rd MPJ of the left and right foot for the control and experimental groups over time.

TREATMENT TIME	LEFT FOOT		RIGHT FOOT	
	CONTROL	EXPERIMENTAL	CONTROL	EXPERIMENTAL
2-3STMPJ_Pressure_0m	318.02 ± 77	281.96 ± 73	279.62 ± 75	256.84 ± 67
2-3STMPJ_Pressure_3m	353.68 ± 89	236.90 ± 65	335.67 ± 89	211.13 ± 55
2-3STMPJ_Pressure_6m	389.53 ± 89	199.07 ± 59	372.92 ± 95	176.18 ± 48

experimental groups in the left and right foot. Based to the results presented at the table 3 and figure 6, it is also noted that the pressure at 2-3rd MPJ was reduced with the use of the sock over time in both the foot (left and right) for the experimental group, while it was in general increased in both foot at the control group. This increase of pressure

at the 2-3rd MPJ for the control group was noted from 318.02 ± 77 to 389.53 ± 89 gr/cm² over time of treatment for the left foot and from 279.62 ± 75 to 372.92 ± 95 gr/cm² for the right foot. These results indicated that not using the innovative sock affects the pressure at the 2-3rd MPJ area.

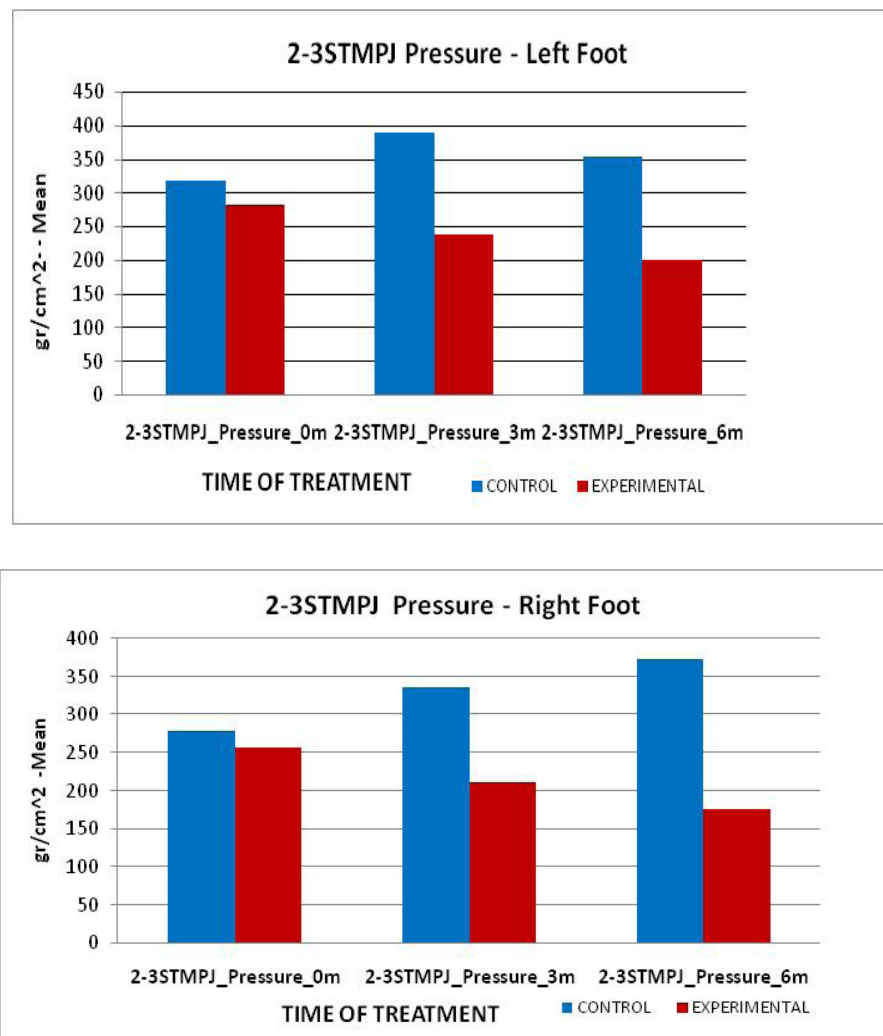


Figure 6. Histograms of pressure at 2-3rd MPJ of the left and right foot for the control and experimental groups over time.

Furthermore, it was noted that pressures at the 2nd-3rd MPJ area for the experimental group were reduced in both the left and right foot, as a result of using the sock. Specifically, the pressure at the 2-3rd MPJ reduced from 281.96 ± 73 to 199.07 ± 59 gr/cm² over time of treatment for the left foot and from 256.84 ± 67 to 176.18 ± 48 gr/cm² for the right foot. These results indicated that using the innovative sock positively affects the pressures at the 2nd-3rd MPJ area, in both feet.

Pressure at 4-5th Mpj of the Control Vs Experimental Groups

Table 4 and Figure 7 below present the descriptive statistics of the mean values and standard deviation for the pressure measurements at 4-5th MPJ over time at 0 months, 3 months and 6 months of treatment for the control and experimental groups in the left and right foot.

Based on the results presented in Table 4 and Figure 7, it is also noted that the pressure at 4-5th MPJ was reduced

Table 4. Descriptive statistics for the pressure at 4-5th MPJ of the left and right foot for the control and experimental groups over time.

TREATMENT TIME	LEFT FOOT		RIGHT FOOT	
	CONTROL		CONTROL	EXPERIMENTAL
4-5STMPJ_Pressure_0m	344.03± 72	304.67 ±73	364.44±71	341.38±74
4-5STMPJ_Pressure_3m	382.03 ± 92	253.28 ± 67	412.80±90	277.35±60
4-5STMPJ_Pressure_6m	417.75± 88	208.46 ± 59	456.95±95	220.93±53

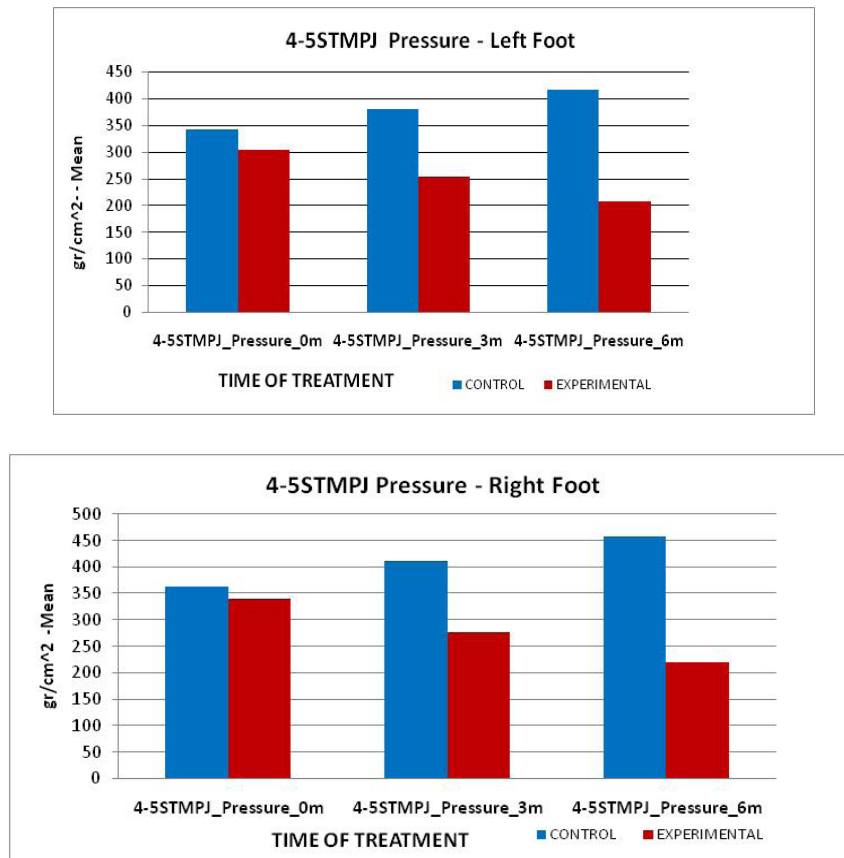


Figure7. Histograms of pressure at 4-5th MPJ of the left and right foot for the control and experimental groups over time.

with the use of the sock over time in both the foot (left and right) for the experimental group, while it was in generally increased in both feet at the control group.

This increase of pressure at the 4-5th MPJ for the control group was noted from 344.03 ± 72 to 417.75 ± 88 gr/cm² over time of treatment for the left foot and from 364.44 ± 71 to 456.95 ± 95 gr/cm² for the right foot. These results indicated that not using the innovative sock affects the pressure at the 4-5th MPJ area.

Furthermore, it was noted that pressures at the 4-5th MPJ area for the experimental group were reduced in both the left and right foot, as a result of using the sock. Specifically, the pressure at the 4-5th MPJ reduced from 304.67 ± 73 to 208.46 ± 59 gr/cm² over time of treatment for the left foot and from 341.38 ± 74 to 220.93 ± 53 gr/cm² for the right foot. These results indicated that using the innovative sock positively affects the pressures at the 4-5th MPJ area, in both feet.

Statistics

The analysis revealed differences in plantar pressures between the control and experimental groups across several regions of the foot. Table 5 presents the results for

the hallux, 1st MPJ, 2-3rd MPJ, and 4-5th MPJ for both the left and right foot.

DISCUSSION

The current study examined, from a biomechanical and clinical perspective, the use of a novel Hallux Valgus (HV) sock on plantar pressure distribution in adults with mild to moderate HV deformity over 6 months of intervention. Findings concluded that the group wearing the sock showed consistently reduced plantar pressures under the hallux, first metatarsophalangeal joint (MTPJ) and medial central and lateral metatarsals, while the control group showed relatively increasing levels of loading to the forefoot. These results provide strong evidence for the sock as an effective conservative intervention for the management of HV.

Comparison of Conservative Treatments with other Studies

The results of this study are consistent with, as well as build on, previously reported conservative treatments or interventions for HV. Taping techniques have been explored and studied widely as short-term corrective treatments. Formosa et al (2017) demonstrated that

Table 5.Statistics for the pressures at Hallux, 1st MPJ, 2-3rd MPJ, and 4-5th MPJ (control vs experimental group).

HALLUX	Left Foot	Right Foot
Between Groups	p=0.708	p=0.801
Control vs Experimental	p <0.001*	p=<0.001*
RM Factor X Groups	p<0.001*	P<0.001*
Bonferroni Post Hoc test -Groups	p=0.001*	p=0.001*
1st MPJ	Left Foot	Right Foot
Between Groups	p=0.121	p=0.953
Control vs Experimental	p <0.001*	p<0.001*
RM Factor X Groups	p<0.04*	p<0.04*
Bonferroni Post Hoc test -Groups	p<0.001*	p<0.001*
2-3rd MPJ	Left Foot	Right Foot
Between Groups	p= 0.047	p= 0.035
Control vs Experimental	p <0.001*	p<0.001*
RM Factor X Groups	p<0.001*	p<0.001*
Bonferroni Post Hoc test -Groups	p<0.001*	p<0.001*
4-5th MPJ	Left Foot	Right Foot
Between Groups	p=0.300	p=0.52
Control vs Experimental	p <0.001*	p<0.001*
RM Factor X Groups	p<0.001*	p<0.001*
Bonferroni Post Hoc test -Groups	p<0.001*	p<0.001*

* indicates significant difference at 0.05%

taping could decrease pain and HV angle, yet only as long as participants were able to sustain the taping intervention, which was also reported to be impacted by compliance and skin irritation. Similarly, Schmitt et al (2019) found a bunion splint to produce decreased angles of the HV over a duration of time but no long-term structural effects.

Additionally, studies using exercise-based interventions have also been tested. For example, Kim et al. (2016) provided evidence that toe-spread-out exercise increases the cross-sectional area of the abductor hallucis muscle and decreases HV angles, while Abdalbary (2018) described physical activity that used exercises in combination with toe separators to improve deformity over 8 weeks. While daily exercise can certainly produce results, adherence to an exercise is a variable difficult to control for, and chronic low-level exercise in older adults and those with multiple medical conditions is appropriately viewed as a challenge.

By comparison, the HV sock provides a non-invasive, simple intervention for both patients and the clinician that produces biomechanical correction with little burden on the patient. In contrast to taping or splinting, the sock is

convenient, fits into footwear easily, and does not require a fitting process. The sustained low-level corrective force of the sock could be a reason for improvement in plantar pressure distribution sustained over six months.

Biomechanical Rationale

The observed significant reduction in hallux pressures in the experimental group provides great support to claim the HV sock positively affects forefoot biomechanics. In HV, the hallux typically deviates to the lateral direction creating abnormal loading patterns that add pressure to the medial metatarsal heads while compromising function of the hallux “push-off” (Mickle et al., 2011). The sock, by stimulating the abductor hallucis and controlling the position of the hallux, seems to have restored a more physiological load-sharing activity in the forefoot.

The evidence of this redistribution of forces is seen consistently at the 1st MTPJ and 2-3rd MTPJs. In untreated HV, similar areas can become overloaded as compensation occurs, resulting in pain and transfer metatarsalgia (Nix et al., 2012). The sock appears to reduce loading in

these areas, which may prevent the cascade of secondary pathologies experienced with HV progression.

Another interesting outcome was the reduction in lateral (4-5th MTPJ) pressures. This shows that the sock in addition to re-centering hallux function improves forefoot stability overall therefore lessening the weight to the lateral rays. With time, such redistribution may slow the development of degenerative changes in adjacent joints, a common observation in chronic HV (Coughlin et al., 2002).

Clinical Implications

The HV sock may offer a viable conservative treatment option that is useful. It is potentially less costly than custom orthoses and/or surgery, which could make it more readily available in the primary care and community context. Additionally, ease of use and comfort may enhance patient compliance and adherence in conservative podiatric treatment regimens, since compliance is an important factor for treatment success.

There may be potential interest for the HV sock in rehabilitation following surgery. Recurrence of HV following surgical intervention remains a major concern, with reported recurrence rates at 10-30% depending on the surgical procedure (Ferrari et al., 2004). A conservative adjunct that may optimize alignment and help reinforce abductor hallucis activation may lessen recurrence and provide surgeons and patients with a viable post-operative management plan.

Although the current findings are encouraging, validation and extension of these findings are warranted. Future trials should include: Larger randomized controlled designs with extended follow-up (12-24 months) to determine the durability of correction and longer-term effects on progression of HV; Comparative trials against existing conservative interventions (toe separators, splints, custom orthotics, structured exercise programs) to contextualize the HV sock in the management hierarchy; Cost-effectiveness evaluations are used to assess economic feasibility at a population level, particularly in healthcare settings where surgical intervention is costly. Subgroup analyses, subcategorizing in terms of age, sex, severity of deformity and foot posture to identify population subgroups seeking improved outcomes; Such research would give a complete understanding of the sock's therapeutic role and inform guidelines to manage HV conservatively in the future.

Limitations reconsidered

The results of this study must be considered with respect to its limitations. The freedom for participants to self-report fidelity of sock use raises the potential for compliance bias. The follow-up length of six months, whilst adequate to drawn preliminary conclusions about the effects of the HV Sock on biomechanical improvement, does not address long-term effects or structural adaptations. The nature of the sample was overwhelmingly female appears consistent with the epidemiology of HV, but limits transferrable generalizability to both sexes. Nevertheless, the effect size and uniformity of biomechanical function and gait materializes good support for the HV sock as a viable intervention.

CONCLUSION

In conclusion, the innovative HV sock triggered statistically and clinically significant alterations in plantar pressure distribution, particularly to address a critical biomechanical feature of HV pathology. By reducing pathological loading of the forefoot and restoring normal function to the hallux, the HV sock can be considered a useful conservative option that is both feasible and effective. Its performance relative to alternatives of care alongside almost no unwanted negative effect, qualifies it as a clinically valuable first-line option for managing HV as well as a viable supplementary treatment in rehabilitation after surgery. Future high-quality research will be important to consolidate the HV Sock's role in podiatric practice.

REFERENCES

1. Abdalbary, M. (2018). Effect of foot mobilization and exercise combined with toe separator on hallux valgus deformity. *Foot & Ankle Specialist*, 11(4), 322-328. <https://doi.org/10.1177/1938640017739284>
2. Bayar, B., Duzgun, I., Baltaci, G., Karacan, S., & Colakoglu, F. (2011). Effects of taping and foot exercises on patients with hallux valgus. *Journal of Back and Musculoskeletal Rehabilitation*, 24(3), 173-179. <https://doi.org/10.3233/BMR-2011-0293>
3. Chevalier, T., Hodgins, H., & Chockalingam, N. (2010). Plantar pressure measurements using an in-shoe system and a pressure platform: A comparison. *Gait & Posture*, 31(3), 397-399. <https://doi.org/10.1016/j.gaitpost.2009.12.004>
4. Coughlin, M. J., Jones, C. P., & Hall, H. (2002). Hallux valgus and first ray mobility: A prospective study.

- Foot & Ankle International, 23(2), 97–101. <https://doi.org/10.1177/107110070202300202>
5. Ferrari, J., Higgins, J. P. T., & Prior, T. D. (2004). Interventions for treating hallux valgus (abductovalgus) and bunions. *Cochrane Database of Systematic Reviews*, 1, CD000964. <https://doi.org/10.1002/14651858.CD000964.pub2>
 6. Formosa, C., Gatt, A., & Chockalingam, N. (2017). A time-series quasi-experimental study to investigate the effectiveness of taping in the treatment of hallux valgus. *Journal of the American Podiatric Medical Association*, 107(2), 120–126. <https://doi.org/10.7547/15-152>
 7. Garrow, A. P., Papageorgiou, A. C., Silman, A. J., Thomas, E., Jayson, M. I. V., & Macfarlane, G. J. (2001). The grading of hallux valgus: The Manchester Scale. *Rheumatology*, 40(5), 491–496. <https://doi.org/10.1093/rheumatology/40.5.491>
 8. Halstead, J., & Redmond, A. C. (2006). Weight-bearing passive dorsiflexion of the hallux in standing is not related to hallux dorsiflexion during walking. *Journal of Orthopaedic & Sports Physical Therapy*, 36(9), 661–667. <https://doi.org/10.2519/jospt.2006.2136>
 9. Hawker, G. A., Mian, S., Kendzerska, T., & French, M. (2011). Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Arthritis Care & Research*, 63(S11), S240–S252. <https://doi.org/10.1002/acr.20543>
 10. Kilmartin, T. E., & Wallace, W. A. (1994). The conservative treatment of hallux valgus: A review. *The Foot*, 4(4), 178–183. [https://doi.org/10.1016/0958-2592\(94\)90026-4](https://doi.org/10.1016/0958-2592(94)90026-4)
 11. Kim, M. H., et al. (2015). Effect of toe-spread-out exercise on hallux valgus angle and cross-sectional area of abductor hallucis muscle in subjects with hallux valgus. *Journal of Physical Therapy Science*, 27(4), 1019–1022. <https://doi.org/10.1589/jpts.27.1019>
 12. McPoil, T. G., et al. (1999). Variability of plantar pressure data. A comparison of the two-step and midgait methods. *Journal of the American Podiatric Medical Association*, 89(10), 495–501. <https://doi.org/10.7547/87507315-89-10-495>
 13. Menz, H. B., Munteanu, S. E., Landorf, K. B., & Zammit, G. V. (2010). Validity of self-assessment of hallux valgus using the Manchester scale. *BMC Musculoskeletal Disorders*, 11, 215. <https://doi.org/10.1186/1471-2474-11-215>
 14. Mickle, K. J., Nester, C. J., Crofts, G., Steele, J. R., & Lord, S. R. (2011). Effects of hallux valgus on plantar pressures and foot pain. *Journal of Foot and Ankle Research*, 4(1), 22. <https://doi.org/10.1186/1757-1146-4-22>
 15. Mickle, K. J., Caputi, P., Potter, J., & Steele, J. R. (2016). Efficacy of a progressive resistance exercise program to improve toe flexor strength in older people. *Clinical Biomechanics*, 35, 128–133. <https://doi.org/10.1016/j.clinbiomech.2016.04.001>
 16. Morley, D., Jenkinson, C., & Fitzpatrick, R. (2013). A structured review of foot pain assessment measures. *Quality of Life Research*, 22(8), 1757–1766. <https://doi.org/10.1007/s11136-012-0294-1>
 17. Morrison, S. C., & Ferrari, J. (2009). Inter-rater reliability of the Foot Posture Index (FPI-6) in the assessment of the paediatric foot. *Journal of Foot and Ankle Research*, 2, 26. <https://doi.org/10.1186/1757-1146-2-26>
 18. Nix, S., Smith, M., & Vincenzino, B. (2012). Prevalence of hallux valgus in the general population: A systematic review and meta-analysis. *Journal of Foot and Ankle Research*, 3(1), 21. <https://doi.org/10.1186/1757-1146-3-21>
 19. Sarwark, J. F. (2010). *Essentials of musculoskeletal care* (4th ed.). American Academy of Orthopaedic Surgeons.
 20. Schmitt, D., Schmitt, J., & Ohly, N. (2019). Conservative treatment of hallux valgus using a bunion splint and taping. *Foot and Ankle Surgery*, 25(3), 312–317. <https://doi.org/10.1016/j.fas.2017.12.007>
 21. Shi, Y., Zhang, Y., Wang, L., Li, H., & Chen, X. (2023). Effects of peak ankle dorsiflexion angle on lower extremity biomechanics during walking and jogging. *Frontiers in Neurology*, 14, 1269061. <https://doi.org/10.3389/fneur.2023.1269061>

22. Van der Leeden, M., et al. (2004). Reproducibility of plantar pressure measurements in patients with chronic arthritis: A comparison of one-step, two-step, and three-step protocols and an estimate of the number of measurements required. *Foot & Ankle International*, 25(10), 739–744. <https://doi.org/10.1177/107110070402501005>
23. Yavuzer, G., Uzumcugil, F., & Karatas, M. (2007). Rehabilitation of hallux valgus: A review. *Clinical Rehabilitation*, 21(5), 397–404. <https://doi.org/10.1177/0269215507073470>
24. Ying, L., Yan, Y., & Zhang, Y. (2021). Effectiveness of conservative treatments for hallux valgus: A systematic review and meta-analysis. *Journal of Orthopaedic Surgery and Research*, 16, 405. <https://doi.org/10.1186/s13018-021-02490-7>

Cite this article: E. Arvanitakis, C. Formosa, A. Gatt, D. Tsirakos, *Biomechanical and Clinical Outcomes of a Novel Hallux Valgus Sock: A Clinical Study II International Journal of Research in Medical and Clinical Sciences*. 2025; 3(2): 48-58.

Copyright: © 2025. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.