Evaluating tibiotalar joint coverage at varying high heel heights

Emily Luo, BS[1], Grayson Talaski[2]; Tania Szejnfeld Mann[3], Aaron Therien, BS[1], Christian Zirbes, BS[1], Kate Kutzer, BS[1], Kevin Wu, BS[1], Kepler Carvalho, MD[1], Nacime Mansur, MD, PhD[4], Cesar de Cesar Netto, MD, PhD[1]
[1]Department of Orthopedic Surgery, Duke University, Durham, NC, USA
[2]Department of Orthopedics and Rehabilitation, University of Iowa, Iowa City, IA, USA
[3]Department of Orthopedics, Federal University of Sao Paulo, Sao Paulo, Brazil
[4]Medstar Orthopedic Institute, Medstar Union Memorial Hospital, Baltimore, MD, USA

Disclosures: Emily Luo (N), Grayson Talaski (N), Tania Szejnfeld Mann (N), Aaron Theiren (N), Christian Zirbes (N), Kate Kutzer (N), Kevin Wu (N), Kepler Carvalho (N), Nacime Mansur (N), Cesar de Cesar Netto (Paragon28, Curvebeam, Disior, Zimmer)

INTRODUCTION: It is estimated that 72% of women will wear high heeled shoes (HH) in their lifetime. While HH are extremely popular, some studies have shown that HH can alter the strain and tension of ligaments in the foot and ankle, increasing risk of ankle instability. Few studies, however, have analyzed the changes in foot and ankle joint mechanics in HH wearers. As HH force the foot and ankle into plantarflexion, it is important to understand the effect of HH on certain articulations such as the tibiotalar joint. Tibiotalar joint coverage has been associated with numerous foot and ankle pathologies including anterior ankle impingement, chronic ankle instability, and progressive collapsing foot deformity (PCFD). In PCFD patients, reduced tibiotalar joint coverage has been shown, likely due to early plantarflexion of the talus over the anterior aspect of the ankle. Additionally, in order to adequately visualize tibiotalar coverage, weightbearing computer topography (WBCT) along with distance/coverage mapping of the tibiotalar joint has provided a promising method for accurately measuring tibiotalar coverage under a physiological load.

The primary objective of this study was to evaluate and trend changes in tibiotalar joint coverage at various HH heights using WBCT and distance/coverage mapping. We hypothesized that as HH height increased, there would be reduced tibiotalar coverage due to increased plantarflexion.

METHODS: 20 healthy, non-frequent HH wearing, volunteers received a total of 4 bilateral WBCT scans: (1) control/no heel, (2) 3 cm heel, (3) 6 cm heel, (4) 9 cm heel. Scans were semi-automatically segmented to create three-dimensional bone mesh models using a commercially available software package. Segmentations were cleaned and confirmed by an expert in the field. Manual selection of the talar dome and the medial/lateral gutters was performed by two readers. To decrease measurement variability, both the segmented bone models and articulating selections were transformed to each consecutive HH height. Distance mapping was used to evaluate the distance between the talar dome and tibia selections (Figure 1). Talar dome uncoverage was defined by distances and areas under a specific threshold distance of 5mm. Percent coverage was calculated by dividing the sum of triangulation areas below the threshold by the total sum of areas. Differences were assessed statistically using paired t-test and ANOVA tests to assess differences between groups. P values < 0.05 were considered significant.

RESULTS: Between all HH heights, there was a significant difference in tibiotalar coverage ($p < 0.0001$). More specifically, while there was not a statistically significant difference in coverage between the 3cm and control group, the 6 cm and 9 cm groups relative to the control had significant differences in coverage ($p < 0.05$). Overall, increasing high heel height was associated with reduced tibiotalar coverage. Results are summarized in Figures 2 and 3.

DISCUSSION: In this study, tibiotalar coverage was assessed for non-frequent HH wearers to further elucidate the impact of HH wearing on ankle stability. While other studies have shown an association between conditions that induce plantarflexion of the talus and reduced tibiotalar joint coverage, this relationship has never been demonstrated nor trended at varying heel heights. Our results show that with increasing high heel height, there is decreasing tibiotalar coverage. These findings are likely associated with the increasing degree of plantarflexion that the foot and ankle are forced to maintain while at varying high heel heights. More specific studies and plantarflexion measurements are needed to better quantify this relationship. This data can be helpful to inform HH wearers of the risk of ankle instability associated with higher heel heights. In conclusion, our results demonstrate that HH increases ankle instability by reducing tibiotalar coverage, while higher heel heights have a greater effect on talar dome uncoverage. Future research on frequent HH wearers may help to determine if there is a chronic effect on ankle stability.

SIGNIFICANCE/CLINICAL RELEVANCE: This study is the first of its kind to analyze changes in tibiotalar coverage in high heels and builds upon the existing literature of ankle instability high heels. Additionally, this study supports the ability to use WBCT and distance mapping/coverage mapping to evaluate tibiotalar coverage.

Figure 1. Tibiotalar and talar dome selections

Heel Height Comparison	Measurement	R/L status	p-value (Welch Two Sample t-test)
0cm vs 3cm	coverage	pooled	0.1613
		R	0.389
		L	0.2617
0cm vs 6cm	coverage	pooled	0.0002747 ***
		R	0.01035 ***
		L	0.003331 ***
0cm vs 9cm	coverage	pooled	1.02 e-14 ***
		R	1.28 e-8 ***
		L	1.66 e-7 ***

Heel Height Comparison	Measurement	R/L status	Pr(>F) (ANOVA)
0cm vs 3cm 6cm vs 9cm	coverage	pooled	1.87e-14 ***
		R	5.12e-07 ***
		L	6.78e-10 ***

Figure 2. Statistical Analysis of high heel height vs tibiotalar coverage. *** = significance

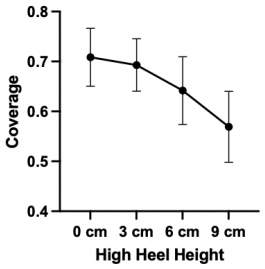

Figure 3. Trend of high heel height vs tibiotalar coverage