

Analysis of Hallux Valgus Angles Using 3D Foot Scans

Ales JURCA ^{*1,2}, Yang Jiao ¹, Sašo DŽEROSKI ^{3,2}

¹ Volumental AB, Stockholm, Sweden;

² Jožef Stefan Postgraduate School, Ljubljana, Slovenia

³ Jožef Stefan Institute, Ljubljana, Slovenia

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Introduction

The hallux valgus angle (HVA), also called first metatarsophalangeal angle, first toe angle, or toe #1 angle, is affected by wearing footwear. HVA larger than 15° is an indicator of hallux valgus (HV), the most common forefoot deformity, which causes foot pain and can alter foot function. Shoe toe box shape [1] and shoe fitting [2] are essential factors influencing the increase of HVA. Women wearing shoes with a narrow toe box between the ages of 20 and 39 are more likely to undergo hallux valgus in later life [3].

HVA is measured as the angle between the first metatarsal and the proximal phalanx. Radiography during weight-bearing is the gold standard to measure HVA; however, this procedure is not suggested for healthy people.

The aim of this study is to analyze the HVA variation in the North American female population using a novel HVA measuring method that utilizes 3D foot scans.

Methods

This study was conducted using a 3D foot scan database of North American female shoe shoppers, who got their feet scanned in one of the footwear brick and mortar stores that use Volumental 3D foot scanners [4]. More than 25,000 female 3D foot scans in the foot length class 245mm (foot length between 242.5mm and 247.5mm) were used in the study. The procedure of scanning feet was described in [4].

The hallux valgus angle was measured as the angle between a base line parallel to the first metatarsal, and a hallux medial line parallel to the hallux proximal phalanx (Fig.1). The base line (the blue dashed line in Fig. 1) was defined by the calculated markers used in foot width and heel width measurements (points *P* and *H* as presented in Fig. 1). The hallux medial line (the red dashed line in Fig.1) is the line parallel to the longest line segment on the hallux convex curve. The angle between the hallux medial line and the base line defines the HVA.

Results

A histogram of the measured HVA values is presented in Fig. 2. The mean HVA is 11.7 ± 6.9 degrees. 26% of the feet have HVA larger than 15 degrees, which indicates hallux valgus – the most common forefoot deformity. The 5th percentile is equal to 2 degrees and the 95th percentile is equal to 24 degrees.

Discussion and conclusion

The main finding of this study is the large dispersion of HVA values of over 25,000 female feet that are very similar in foot length. The range between the 5th and the 95th percentile is 22 degrees. It is very likely that a specific forefoot shape of a shoe does not fit to the wide range of HVA values observed in this study. Footwear brands should be designing shoes with different forefoot shapes in order to provide perfect fit in the first toe area to the majority of their customers.

Hallux valgus angle is an important quantitative measurement of toe shape, and an indicator of foot health. More than a quarter of female customers in this study have HVA larger than 15°, which is an indication of hallux valgus (HV). This figure indicates that customers should pay more attention to wearing the proper size of footwear. They should also make sure that the toe box matches their first toe angle. Footwear producers should pay attention to designing anatomically shaped footwear to reduce the impact of poorly fitting shoes on feet.

* ales.jurca@volumental.com; www.volumental.com

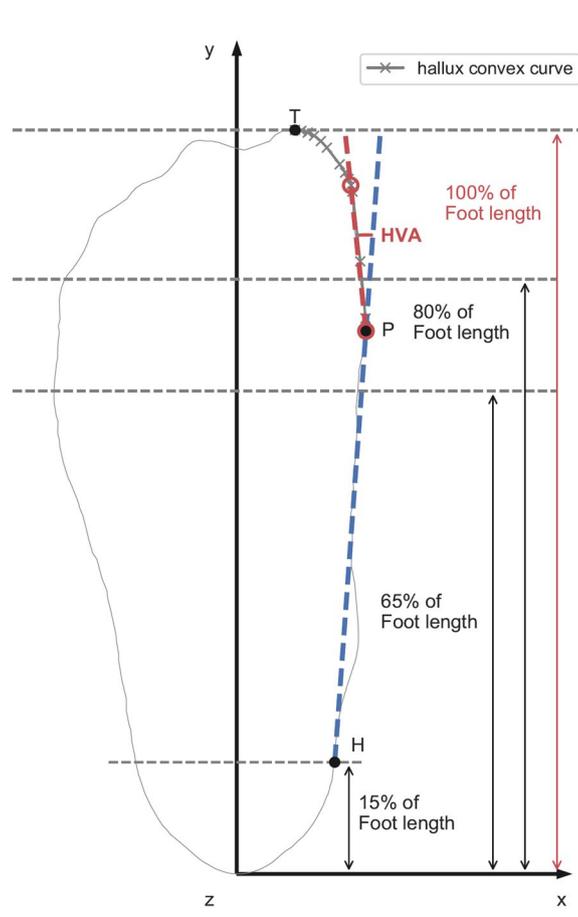


Fig. 1. The measurement of hallux valgus angle from a 3D foot scan

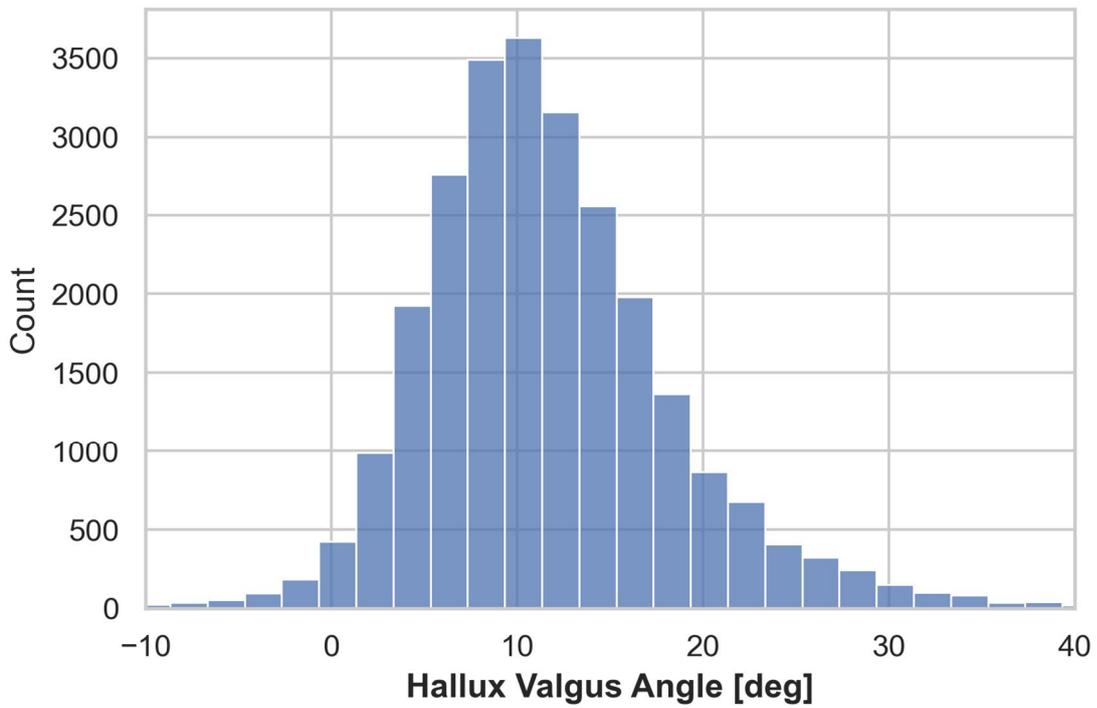


Fig. 2. Histogram of HVA of North American female customers in length class 245mm

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