

DETERMINATION OF A THEORETICAL BALL LINE

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INTRODUCTION

The ball line is the line between the two anatomical ball points (medial and lateral ball points). When taking foot measurements by hand, these ball points can be felt. Nowadays 3-dimensional foot scans are more and more used in foot measuring. In the TNO software for foot measurements, the anatomical ball points are automatically determined in the foot scans (by shape recognition). However, it is not always possible to determine the correct anatomical ball points. Particularly the lateral ball point is often difficult to determine.

In literature the ball line is generally assumed to be the line through the foot centre with a ball angle of 80°. The foot centre lies on 62% of the total insole length. In shoes for adults the insole length is 15 mm larger than the foot length. In this study the validity of these assumptions is examined and it is verified if it is possible to determine the ball line from a theoretical position of the foot centre depending on foot length and the ball angle.

METHODS

In this study 134 male volunteers on active Dutch military duty participated. They are all from western-european origin and do not suffer from severe foot problems. The age of the volunteers varies between 18 and 30 with a mean age of 22 (standard deviation is 3). The right feet of the subjects were scanned with a Pedus foot scanner [www.human-solutions.com]. These scans were used as input for the TNO software for automatic determination of anatomical foot measures.

RESULTS

The position of the foot centre (as a percentage of insole length) and the ball angle are determined from the scans. The foot centre is defined as the point at 5/12 of the ball line measured from the medial ball point. The ball angle is the angle between the ball line and the foot axis (line through heel point and foot centre). The results are presented in figure 1.

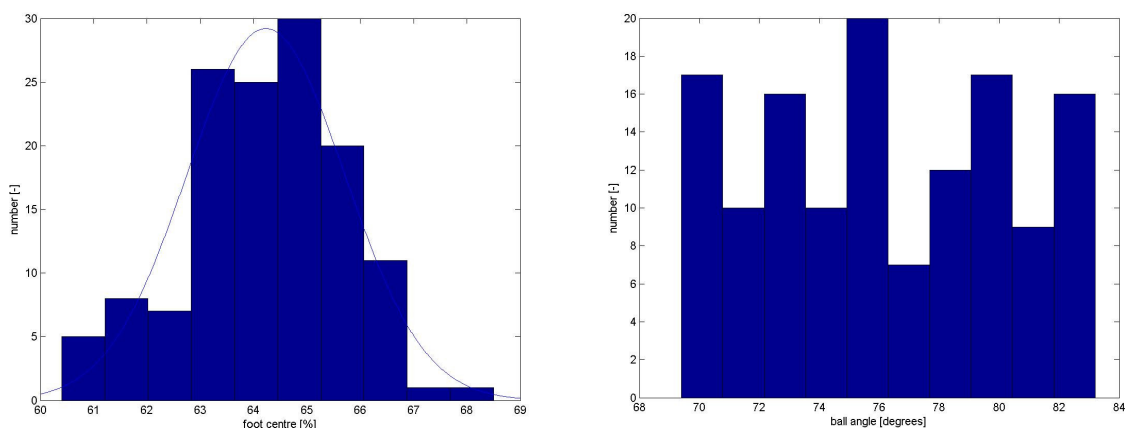


Figure 1: Left: Distributions of position of the foot centre. Right: Distribution of ball angle.

In the left figure the distribution of positions of the foot centre is plotted. The mean value equals 64.3% with a standard deviation of 1.5%. The corresponding Gaussian distribution is also plotted in the figure. A Kolmogorov-Smirnov test of normality is performed and confirmed a Gaussian-like distribution (sign. $0.2 > 0.05$).

In the right figure, the distribution of the ball angle is plotted. The mean value equals 78.9° with a standard deviation of 4.13° . There is no Gaussian-like distribution (Kolmogorov-Smirnov test of normality, sign. $0.041 < 0.05$).

For both the position of the foot centre and the ball angle it was found that there is no correlation with foot length.

DISCUSSION

In literature it is assumed that the position of the foot centre is at 62% of the total insole length and the ball angle is 80° . With these values, lasts and shoes are designed and produced.

In the foot scans the mean position of the foot centre is 64.3% (std 1.4%), which is 2.3% larger than generally assumed. Because of the small variations in found positions (std 1.4%) and a Gaussian distribution, it is concluded here, that the position of the foot centre can be determined with this percentage, without determining the ball points first. It should be mentioned that this percentage of 64.3% is only valid for people that have the same properties as the group examined here: healthy western European men, age between 18 and 30, no foot problems.

The mean ball angle equals 78.9° (std 4.13), which is 1.1° smaller than in theory. In contrast with the position of the foot centre, there is a large variation of the ball angle and all occurring angles are present with a certain number. There is no relationship with foot length, so in advance it is not known which ball angle to use for a certain foot. In a future research it could be examined to what extent the ball width varies using the minimum and maximum occurring ball angle.

Because of the small variation in foot centre position and the large variation in ball angle, an intermediate approach to determine the ball line is recommended here. Based on the foot length the position of the foot centre can be determined with the percentage of 64.3%. The anatomical medial ball point can be determined from the foot scan, as we used to do. The ball line is now defined as the line between the anatomical medial ball point and the foot centre.

The reason that the position of the foot centre is a percentage of the total foot length and is the same percentage for all adult male foot lengths in this group, means that the relative length growth of all foot bones is the same for all healthy feet. The ball angle is obviously determined by other aspects of the foot. It is assumed that the posture of the foot and ankle plays an important role. In this study the foot type (varus, valgus) is not taken into account, but it is worth examining whether there is a relationship between foot type and ball angle.

REFERENCES

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