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Application of Simple Foot Shape Measuring Device in the Process of Shoe Selection

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Abstract

Foot shape measurement is a key technology to obtain foot shape and size data, which is crucial for footwear design, production, and the comfort and health of consumers wearing shoes. The purpose of this paper is to discuss the method and technique of foot shape measurement and its application in footwear design and comfort evaluation. Combined with the simple foot shape measuring device designed and developed by the author, a foot shape measuring device with simple structure design and its application in the process of shoe selection are discussed. Through the comparison of different measuring equipment and the analysis of the relationship between foot shape data and footwear design, it provides a useful reference and guidance for footwear industry.

Keywords

Simple Device; Foot Shape Measurement; Choose Shoes; Development and Application.

1. Introduction

The human foot has a unique shape. When the foot is standing or walking with the weight, the binding of the shoe products on the foot and the matching degree of the shape determine the comfort of the shoe products. Therefore, the acquisition technology of human foot shape has always been paid attention to by shoe manufacturers. The collection and analysis of foot shape data and the design of footwear products that meet foot shape characteristics have always been the focus of shoe manufacturers.

A range of techniques have been used to capture and analyze foot shapes, from visual assessment, anthropometry, to footprints, X-rays, ultrasound and magnetic resonance imaging. However, these methods are usually limited by linear two-dimensional measurement methods and cannot accurately achieve the purpose of obtaining the three-dimensional shape of the foot. With the development of technology, 3D scanning technology has been applied to study the change of 3D foot shape. Considering the advanced nature of 3D measurement technology and the expensive level of equipment, it is difficult for existing enterprises to promote the application of 3D scanning technology to carry out foot shape measurement. However, from the perspective of matching the shape of foot and footwear products and improving the wearing comfort of shoes, the key indicators affecting the matching of footwear products and foot shape do not cover all foot shape data. It is of great significance to design and develop a simple device which can obtain the key indexes of foot and meet the demand of footwear selection. In order to achieve this goal, this study uses the principle of mirror reflection to design a plantar shape test bench that can collect the plantar shape of the test subjects. In addition, three healthy children are selected to stand on the plantar shape test bench with bare feet and record the marks of plantar shape, foot length, foot width and other indicators, so as to meet the key indicators of targeted foot shape testing for children when choosing footwear products. Through the application of children's shoe selection and fitting, it shows that the designed plantar shape test bench can prepare and collect the key index data of children's foot shape,

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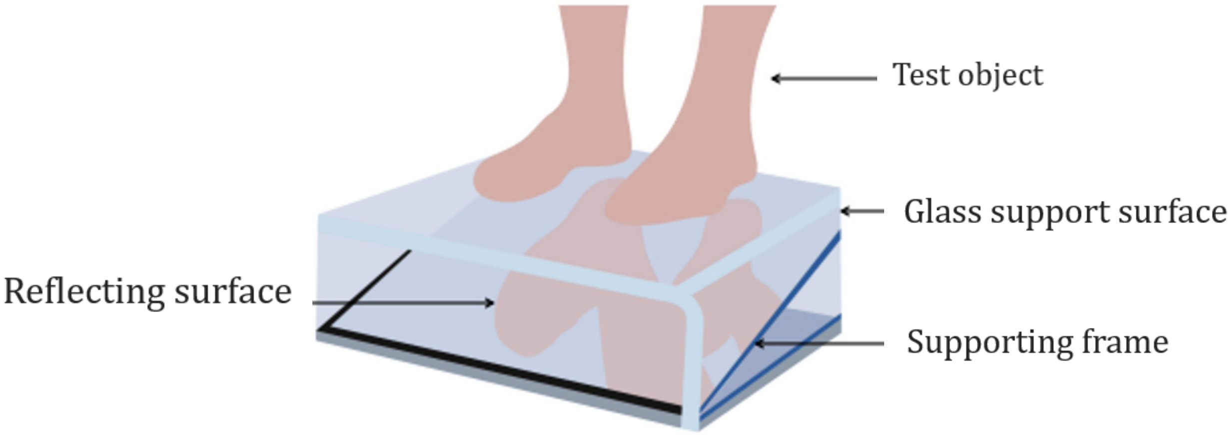
meet the need of matching foot shape data and shoe product data in the process of children's shoe selection, which is of great significance for children's shoe selection.

2. Test Device Key Technology

2.1. Foottype Measuring Instrument Structure

The simple foot type test device is mainly composed of reflecting mirror, supporting platform, frame structure and marking structure, and the overall structure is shown in Figure 1. The reflecting mirror is placed on the bottom surface of the measuring platform at a 30° Angle, the mirror direction is upward, the glass support surface is strengthened by tempered glass, which can bear the weight of the tester. The coordinate system is set on the glass support surface, the minimum unit is mm, and the maximum longitudinal distance is 350mm, and the maximum transverse distance is 440mm. Children with different foot sizes are measured. In the arch part of the two feet, the corresponding glass support surface is designed with the arch test mark line, the length is designed to be the same for the left and right feet, and the left and right sides are 50mm respectively. The design of the foot type test table can directly feedback the length, width, contour shape of the foot and the height of the arch of the tested child based on the standing footprints of the tested child. Through the position of the arch test mark line, the size of the contact glass support surface of the tested arch is tested. The larger the contact surface, the lower the arch is indicated, and the smaller the contact surface, the higher the arch is indicated.



(a) Device block diagram

(b) Device element collection

Fig 1. Simple foot type test device structure

2.2. Device Surface Marking Line Setup

In order to accurately obtain the key indicators of the foot of the test object, an identification line was designed on the glass support surface of the device, in which the maximum longitudinal distance was 350mm and the maximum transverse distance was 440mm. In the arch position opened on the two feet, the corresponding glass support surface was designed with an arch test line, whose length was designed to be the same on the left and right feet, and the left and right sides were 50mm respectively. When the test object stands on the surface identification line of the glass support surface, the data such as the foot length of the test object, the width of the front palm of the foot, and the contact area of the foot arch of the test object will be reflected on the mirror surface, so as to help the design and development personnel intuitively understand the foot data of the test object, and select different series of products according to it, and help the test object choose to wear the appropriate size and comfortable footwear products.

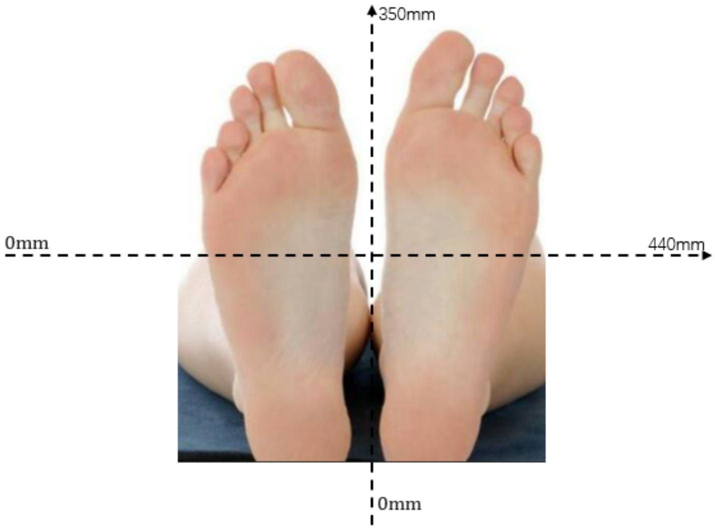


Fig 2. Support surface length and width mark line

2.3. Foot Image Data Processing

Plantar image is the main basis of foot shape measurement system to calculate foot length, foot width, foot bow width and other parameters. Plantar image processing is mainly based on the identification line of the supporting glass surface, including the longitudinal foot length index, the widest point on both sides of the metatarsophalangeal joint of the forefoot is recorded according to the starting point of the heel of the plantar print to the maximum point of the toe, and the transverse width index. The arch index mainly investigates the contact area of the arch. Observe the contact between the arch and the support glass surface. The more contact between the support surface of the arch, the lower the arch is; the less contact, the higher the arch is. The above data of sole length, sole width, and arch contact area can be used as the basis for matching key data such as shoe length, shoe width, and insole arch support during the selection of shoes for test objects. As shown in the figure below, the length of the sole of the test object is 195mm, the width of the sole is 79mm, and the arch index is 40mm.

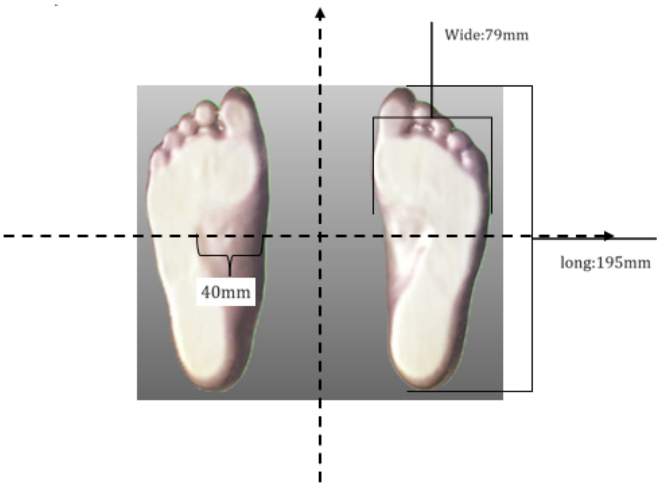


Fig 3. Plantar printing data processing

Different from the plantar length and plantar width data test, the arch evaluation of the test object is mainly based on the arch identification line set on the glass support surface. The length of the identification line is the same on the left and right side, and the length is 50mm respectively. When the contact area of the arch is large, the arch identification line has more contact with the skin of the arch, indicating a low arch. When the contact area of the arch is small, the contact between the arch identification line and the arch skin is less, indicating a high

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arch. The evaluation of the arch is in line with the preferences of existing consumers when choosing shoes. The selection of arch support insoles with different heights for different test subjects can maximize the contact between the sole and the insoles, thus dispersing the sole pressure. At the same time, different support structures are selected for different arch characteristics, which can effectively make up for the support and cushioning capacity that different arches do not have.

3. Reliability Verification of Test Equipment

3.1. Length Verification

In order to verify the use value of the plantar test device in the actual shoe selection process of children, after the device is completed, three test children are selected to collect and compare the key data of foot morphology by using the three-dimensional foot scanner and the plantar test device designed in this study, so as to verify the value of the simple test device in the actual shoe selection process. The sole data of the test subjects were collected respectively. The length, width and arch of the foot were respectively collected.

Fig 4. Plantar morphology acquisition

Firstly, based on the plantar length data of the test subjects, three-dimensional foot scanner and simple plantar test device were used respectively to compare the plantar length data of the test subjects. The test subjects were three children, and the foot length test results of the three children were compared as follows:

Table 1. Foot length test comparison

	Foot length (mm)	Foot length (mm)	Foot length (mm)
3D foot scanner	233.88±0.21	232.15±0.15	226.72±0.19
Plantar test device	233±1	230±1	225±2

Three-dimensional foot shape scanner and simple sole shape acquisition device designed in this research were used to collect foot shape data of test subjects, and three key indicators of shoe selection were mainly compared. The test results showed that, the foot length sizes of the three test subjects were 233.88±0.21 (mm), 232.15±0.15 (mm) and 226.72±0.19 (mm), respectively. The foot length of the three test subjects was 233±1 (mm), 230±1 (mm) and 225±2 (mm), respectively, by using the proposed plantar morphology acquisition device involved in this study. Compared with the two different devices, the foot length data of the test subjects was collected by using the three-dimensional foot scanner with higher accuracy. Using the simple plantar morphology acquisition device designed in this study, the data accuracy is slightly lower, and the data collected by the two devices are close to each other. Due to the subtle morphological changes of feet every day, the elasticity of footwear materials and the design of internal excess space, combined with the results of foot length data collection, the plantar morphological collection device designed in this research can fully assist test subjects to select footwear products of appropriate size.

3.2. Width Verification

Compared with the measurement of foot length, the width of the foot is more important for the comfort of footwear products, the main reason is that the current domestic shoe design is generally set according to the length, and the width of the shoe is often a unified standard, which makes it difficult for consumers to choose different widths in the process of shoe selection. Therefore, the plantar shape acquisition device designed in this study can obtain the width of the front palm, which is conducive to the width of the foot when selecting different styles of footwear products. At the same time, it can also promote the consideration and innovation of shoe width design in the design process of footwear products in the future.

The three-dimensional foot scanner and the plantar morphology acquisition device designed in this study were used to test the plantar morphology of 3 test subjects, and the width data of the forepaw were analyzed and recorded. The test results of the three-dimensional foot scanner were 79.39±0.13 (mm), 83.45±0.31 (mm) and 88.95±0.11 (mm). The test results of the simple plantar morphology testing device designed in this study were 81±1 (mm), 79±1 (mm) and 87±2 (mm). The comparison between the two devices showed that the simple plantar morphology acquisition device designed in this study tested the width of the front palm, and the accuracy of the test device designed in this study could not reach the level of three-dimensional foot scanner. However, considering the deformation of the foot and the deformation of the upper material itself, the deviation of the millimeter level can not affect the wearing comfort of footwear products.

Table 2. Foot wide test comparison

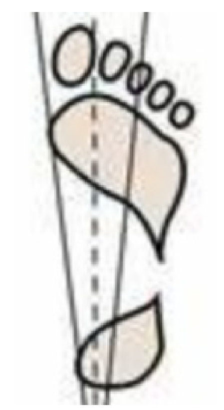
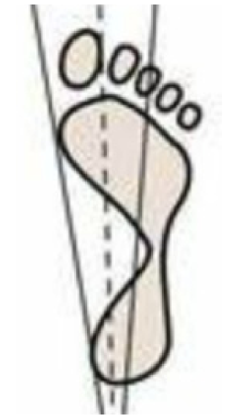
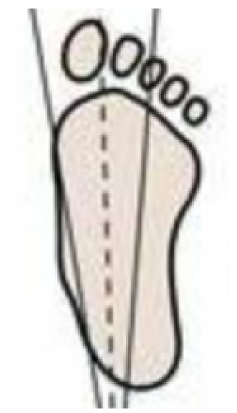
	Foot wide (mm)	Foot wide (mm)	Foot wide (mm)
3D foot scanner	79.39±0.13	83.45±0.31	88.95±0.11
Plantar test device	81±1	79±1	87±2

3.3. Arch Verification

The plantar shape acquisition device designed in this study is mainly designed to set three key indicators in the process of shoe selection. In addition to foot length and foot width, the arch test is particularly important. In order to obtain the arch data, it is of great importance to assist enterprises in designing footwear products that meet the arch shape of consumers. The development of this device will also actively promote the design innovation of footwear products.

The contact area of the arch of the foot is measured by the horizontal marking line designed on the glass support surface. When the contact area of the foot arch is large, the contact length of the label line is large, indicating that the foot arch is low; when the contact area of the foot arch is small, the contact length of the label line is small, indicating that the foot arch is high. According to the characteristics of different arches, the identification line is set to 50mm, and the characteristics of different arches are divided according to the length of the contact identification line as follows: when the identification line is not contacted at all and the display length is greater than 50mm, the arch type of the test object is High arch; when the identification line is partially contacted and the display length is in the range of 40-50mm, the arch type of the test object is high arch. At this time, the arch type of the test object is Higher arch. When the marking line is partially touched and the display length is 20-30mm, the arch type of the test object is Normal arch. When the marking line is fully touched and the display length is 10-20mm, the arch type of the test object is Low arch. When the marking line is fully touched and the display length is greater than or equal to 50mm, the arch type of the test object is Severe low arch. This method can be used to divide the test objects of different arch types, which can easily obtain the arch characteristics of the test objects, so as to facilitate enterprises and shoe buyers to select footwear products with different arch support characteristics according to the arch characteristics of the test objects, and achieve the goal of matching the shoe products with the arch shape of the wearer.

Table 3. Grading of the arch

High arch	Higher arch	Normal arch	Low arch	Severe low arch
>=50mm	40-50mm	20-30mm	10-20mm	<=50mm
				

4. Practical Application Effect of Plantar Measuring Device

The ultimate goal of this study is to help consumers choose the best matching step shape when the designed plantar shape collection device is applied to the actual footwear sales. To this end, according to the test results of the three test subjects in the above study, the measurement results of their foot morphology were selected, and three suitable footwear products were selected respectively to verify the accuracy of the device. The test results show that the footwear products selected by using the measured data obtained by the simple plantar shape acquisition device can fully achieve the goal of matching the foot type. In addition to the matching between the footwear and the foot length and width of the consumer's foot, the arch testing and footwear matching effect are more obvious. The footwear products with arch support pads designed for different foot arch characteristics are designed. Effectively meet the current market of the vast majority of footwear products lack arch support pad design, to meet the consumer's arch cannot fully contact with the insole, footwear products cannot be based on the characteristics of the wearer's arch for effective support and protection of the objective needs. The matching level of the design of different parts of shoes was evaluated according to the fitting evaluation score of shoes. Each index was calculated according to the 4-level score, including very fit (4 points), fit (3 points), not fit (2 points), very not fit (1 points). The results of the test subjects' matching level of footwear are as follows:

The test results showed that the sole morphology data of the three test subjects were selected to try on different footwear products, and comprehensive scores were obtained from the feedback. The results showed that the average score of the comfort evaluation of the three test subjects on the selected footwear products was higher than the comfort level, and one test object scored full marks on the comfort evaluation of the selected footwear products. The matching of plantar length, plantar width and arch support were satisfactory.

Table 4. Shoe fitting feedback sheet

	Foot length matching	Foot width matching	Arch matching	overall score
Test object A	O very fit O fit O not fit O very not fit	O very fit O fit O not fit O very not fit	O very fit O fit O not fit O very not fit	13
Test object B	O very fit O fit O not fit O very not fit	O very fit O fit O not fit O very not fit	O very fit O fit O not fit O very not fit	14
Test object C	O very fit O fit O not fit O very not fit	O very fit O fit O not fit O very not fit	O very fit O fit O not fit O very not fit	13

5. Conclusion

In view of the current situation that consumers often choose suitable footwear products through repeated fitting during shoe selection in the market, resulting in prolonged transaction time and energy consumption, this paper designed and developed a simple plantar morphometry device, and designed three key shoe matching indexes such as foot length, foot width and arch contact surface. The test accuracy of the device is compared with that of the advanced 3D foot scanner. The comparison results show that the test accuracy of the device is close to that of the advanced 3D foot scanner, which fully meets the shoe selection needs of the children's test objects, and the corresponding footwear products are selected according to the test results for fitting feedback collection. The fitting test results showed that the three test subjects were satisfied with the footwear products selected for the foot shape data, and one test subject was completely satisfied. In this paper, based on the principle of mirror reflection, the marking line is designed on the glass support surface of the device, which can intuitively read the data of foot length, foot width and foot arch characteristics, and its accuracy can meet the demand of footwear product selection, and has broad market application value.

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