Research on the Relationship of foot Morphology Changes and Heel Height

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Abstract: In this paper, by using flat foot pressure testing equipment, the changes of human Forefoot size in different heel height were measured and analyzed, and the changing rules of forefoot stress area and ball girth were gotten. In addition, the result could provide design location and pressure reference for shock absorption insole.

Key words: heel height; ball girth; stress area

1 Introduction

Footwear industry has a long history, which has already from the wearing shoes-conscious period. For footwear products, heel height is the major influencing factor of foot pressure. In the original state of the human body, backfoot heel is the main bearing parts of gravity, in which the lower edge of the calcaneus is mainly affected by the body center of gravity point, which is in the center of heel.But a certain degree of heel has made the original mechanical state of the foot changed dramatically, which increases the pressures of forefoot.

2 Testing part

2.1 Testing Instrument

This experiment is used the Footscan Single step Mat system–USB, produced by Rsscan Company in Belgium.

2.2 Testing Principe

In different heel heights, measuring the changes of the forefoot shapes, mechanical parts, and the foot motion, in standing and walking. This experiment is installed the heel in the foot, to reach the same mechanical effects with their high-heeled shoes, and to make the testing personnel have the similar feeling between wearing self-made heel and wearing the same height heels shoes. Testing personnel, barefoot or wearing different heel heights, to walk through the pressure plate in their natural states, then the computer will appear data and images of testing personnel's foot pressure.

2.3 Experimental Objective

The study selects for the nine female college students, of whom 22-year-old are seven, 23-year-old is one, 24-year-old is one, whose average height is 163.22cm, average weight is 50.89kg, average shoe size of testing person wearing is 37.33, of which 39 has two person, 38 has two, 37 has two, 36 has three. The fat-sized feet has one person, thin-sized feet has one, medium-sized feet have seven, the average ball girth below 20mm heel height is 223mm. Nine experimental objectives don't have a long history of wearing high-heeled shoes.

In the 20~ 100mm heel height, measuring the ball girth of the testing personnel (barefeet), the steps are as follows:

(1) Firstly, testing personnel perpare, and then take their shoes and socks off, demarcate the first and fifth out point of sole joint.

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Tab.1 Basic information on Experimental objectives

Order number	Height(cm）	Weight(kg)	Code(France code)
1	169	60	39
2	163	49	38
3	160	45	36
4	161	49	36
5	172	52	39
6	157	53	36
7	161	48	37
8	163	52	37
9	163	50	38
Average value	163.22	50.89	37.33

(2) Testing personnel, in turn wearing the heels with 20 ~ 100mm, are in standing state.

(3) According to the mark points, testing workers measure the ball girth with flexible rule in different heel heights and record the data.

(4) Every 30 seconds, repeating the test steps (3) at least 3 times, in order to obtain the multiple testing data in the same state.

(5) Changing other testing personnel, and then repeating the test steps (1) ~ (4).

3 Results and discussion

3.1 Changes of Ball Girth in Different Heel Height in the Static State

Tab.2 Nine testing personnel's ball girth in the 20 ~ 100mm heel height in the static state

Order number	Ball girth in different heel height								
	20	30	40	50	60	70	80	90	100
1	238	240	241	243	246	249	254	258	246
2	226	227	228	231	233	234	233	229	225
3	222	226	227	227	227	228	222	222	221
4	220	222	224	228	225	226	224	224	222
5	226	227	228	226	228	228	233	231	226
6	228	230	231	231	232	228	227	226	225
7	214	216	217	216	219	219	217	215	214
8	223	225	228	228	229	231	233	233	226
9	220	221	222	225	225	227	227	221	218
Sum	2013	2030	2045	2055	2063	2070	2070	2059	2023
Average	223.67	225.56	227.22	228.33	229.22	230.00	230.00	228.78	224.78

Figure 1 shows ball girth's change curves of nine testing personnel wearing a 20mm ~ 100mm heel height in the static state.

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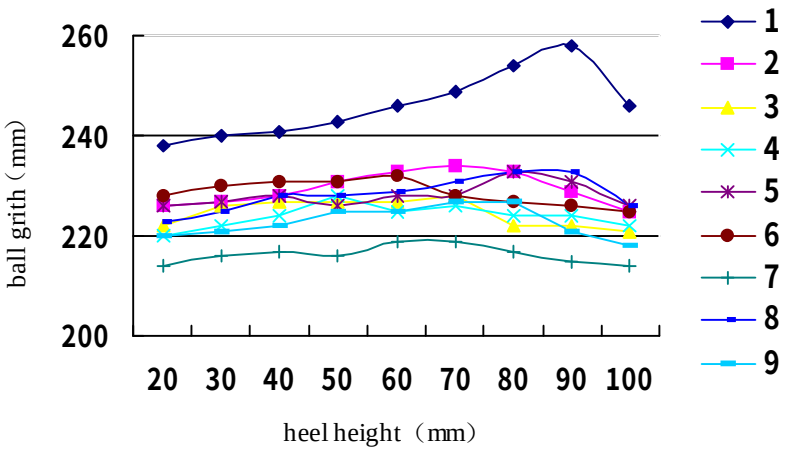

Fig.1 Changes of ball girth in different heel height in the static state

From Table 2 and Figure 1 we can see when the testing personnel wears a 20mm ~ 70mm, as heel height increases, in the static state, the foot ball girth is increasing in the range of 1mm～3mm. Specific increasing rate varies from person to person. When the heel height is more than 70mm,the 67% of testing personnel show, with the heel height increased, the foot ball girth began to decrease; when the heel height is more than 80mm, the 89% of testing personnel show that, with the heel height increased, the foot ball girth starts to decrease; when the heel height is more than 90mm, all the testing personnel show that, with the heel height increased, the foot ball girth starts to decrease.

Figure 2 shows, with the heel height increased, ball girth's average change of nine testing personnel. From that we can see, in 20mm～70mm heel height, with the heel height increased, in the static state ,the foot ball girth increases; in 80mm～100mm heel height, with the heel height increased, in the static state, the foot ball girth decreases, and the decreased-range of ball girth is greater than the increased-range.

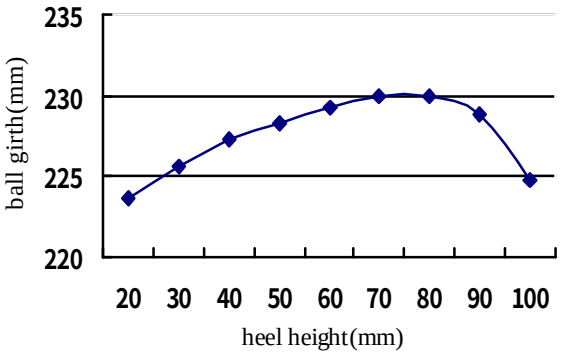

Fig.2 Changes of ball girth in different heel height in the static state

3.2 Changes of Forefoot's Landing Size in Different Heel Height in the Walking State

(1) Changes of forefoot landing part's inclined width in different heel height walking in the flat ground

Here the inclined width is similar to the line of the first and fifth sole joint, and the two widest points when the foot langing in the ground. From Table 3 we can see, with the heel height increased, inclined width decreases; with the high increased from 0mm to 30mm, inclined width decreases in the range of the average 1.5mm; with the high increased from 30mm to 60mm, inclined width decreases in the range of the average 4mm; with the high increased from 70mm to 100mm, inclined width decreases in the range of the average 1.5mm; this trend sees Figure 3.

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Tab.3 Changes of forefoot landing part's inclined width in different heel height walking in the flat ground (unit:mm)

Heel height	0	20	30	40	50	60	70	80	90	100
Inclined width	79	77	76	72	69	63	63	61	60	58

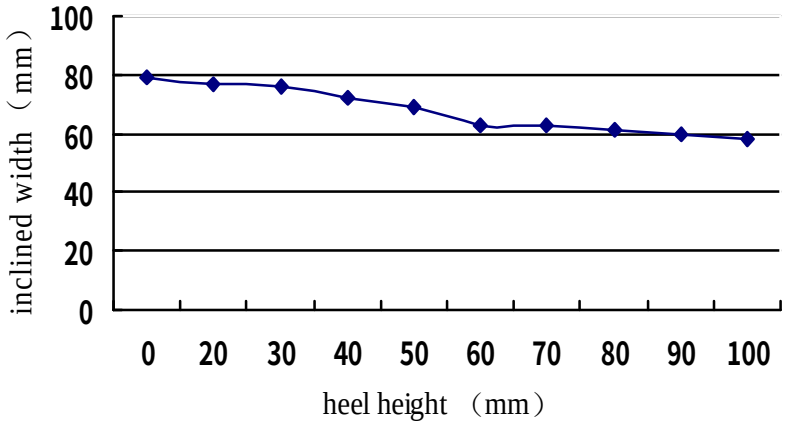

Fig.3 Changes of forefoot landing part's inclined width in different heel height walking in the flat ground

(2) Changes of forefoot landing size in different heel height walking in the flat ground

From Table 4 and Figure 4,we can see, with the heel height increased, the forefoot's landing size is ever-changing: in barefoot state, the landing size is the largest, when the heel height is 100mm, the landing size is the smallest. From the Figure 4 we can see, with the heel height increased from 20mm to 70mm, the forefoot's landing size has a slight change, when the heel height is more than 80mm, the heel for each additional 10mm, the forefoot's landing size decreased averagely 4.15cm$^{2.}$

Tab.4 Changes of forefoot landing size in different heel height walking in the flat ground

Heel height（mm）	20	30	40	50	60	70	80	90	100
Landing size（cm^2）	50.08	49.63	51.95	51.47	50.30	49.87	48.13	43.37	38.77

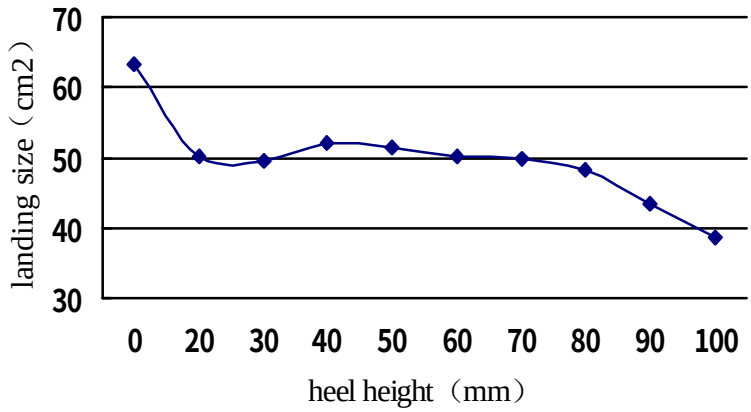

Fig.4 Changes of forefoot landing size in different heel height walking in the flat ground

4 Conclusions

Heel is the main factor to change the force in the course of the wearing shoes, this article analyses the relationship on the changes of the length of ball girth, forefoot's pressure, forefoot's landing size, and heel height, which will provide the basis for the forefoot's design of the high-heeled shoes, at the same time,

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provide the guider to make women wear shoes healthily.The analysis of footscan pressure is the forefront of the subject for footwear, and also is the growing concern of the subject in the field of footwear product design.

The following results are based on the experiments：

(1) When the heel height is in 20mm～70mm, with the heel height increased, the ball girth is in the range of 1mm～3mm increasing. When the heel height is more than 70mm, with the heel height increased, the ball girth began to decrease.

(2) With the heel height increased, inclined width decreases; with the high increased from 0mm to 30mm, inclined width decreases in the range of the average 1.5mm; with the high increased from 30mm to 60mm, inclined width decreases in the range of the average 4mm; with the high increased from 70mm to 100mm, inclined width decreases in the range of the average 1.5mm.

(3) With the heel height increased, the landing size of forefoot is ever-changing: in barefoot state, the landing size is the largest, when the heel height is 100mm, the landing size is the smallest. From the Figure 4 we can see, with the heel height increased from 20mm to 70mm, the forefoot's landing size has a slight change, when the heel height is more than 80mm, the heel for each additional 10mm, the forefoot's landing size decreased averagely 4.15cm^2.

In this paper, we can draw five conclusions, which can provide strong support for the forefoot pattern's design of women lasts having the various back high level, the design of forefoot's size, shape, position, and the last ball girth and so on; Changes on inclined width in different heel heights can provide reference data for the length of women soles having the various back high level; Changes on all parts of forefoot's pressure and size can provide a reliable location point of design and the a reference of pressure data for damping, cushioning performance insoles, midsole, special function shoes (such as orthopedic shoes);at the same time, can provide a strong mechanical explanation for the foot's injury which causes by high-heeled shoes.

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