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Biomechanical analysis on force plate of aerobics shoes

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Abstract. A pair of good shoes is essential to aerobics, especially a pair of professional aerobics shoes featuring shock absorption and injury avoiding. Huakang shoes, Reebok shoes (RBK) and gymnastics shoes are selected as experimental subjects. Experiments on force plate of shoe sole and plantar pressure are conducted to measure mean force value, FT value, PP (Peak Pressure) value and MF value of 12 female aerobics athletes and kinetic analysis is conducted to analyze those data. Thus, some useful references are provided for designing aerobics shoes. Study results show that in experiment on force plate of shoes sole, PP value and MF value of bare foot rank the first and the values of Reebok shoes rank the second among those experimental subjects. Huakang shoes are proved to be better than Reebok shoes in terms of reducing movement FT and pressure. In experiment on plantar pressure, Mean force of Huakang shoes rank the first, FT value and MF value of Reebok rank the first and PP value of bare foot rank the first among those experimental subjects. It proves that Huakang shoes are better than Reebok shoes in terms of reducing FT of ground on foot and reducing vibration during exercise.

Key words. Aerobics shoes, force plate, plantar pressure, biomechanics.

1. Introduction

Medically, feet are regarded as "the second heart" of human, thus both walk and health are influence by shoes [1]. Comprehensively, production requirement of sport shoes was the strictest one among all kinds of shoes. Modern sport shoes should not only be durable and comfortable but also should meet requirement of different sport events to improve performance of athletes [2]. Aerobics is a form of physical exercise for improving health, shaping body and entertaining [3]. With the development of competitive sports, aerobics has developed into an independent sports competition, in which aerobics shoes is of vital importance. Professional aerobics shoes are able to adjust feet load when landing and reduce impact force of athlete when landing, thus sport injury is reduced indirectly.

So far, there are many studies about shoes for basketball and football, S. Zhang et al. [4] studied influence of midsole density of basketball shoes to rebound landing

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of players. E. M. Hennig et al. [5] studied athletic ability display and its injury with different soccer shoes. However,there are few studies about aerobics shoes. Even fewer studies are focused on foot injury of aerobics athletes from plantar pressure of frequent lower limb movements [6]. Huankang shoes, Reekbok shoes and gymnastics shoes are selected as experimental subjects. Experiments on force plate of shoe sole and plantar pressure are conducted to analyze characteristics of plantar pressure of frequent technical movement. Thus, plantar pressure of different technical movement and different shoes are studied to provide a biomechanical reference for designing and producing aerobics shoes.

2. Experimental subjects and method

2.1. Experimental subjects

Three kinds of shoes were selected as experimental subjects, among which two of them were domestic brands for producing professional aerobics shoes – Huakang specific-aerobics shoes for competition and Reebok specific-aerobics shoes for competition (Hereinafter referred to as Huakang shoes and Reebok shoes respectively). The other shoes were gymnastics shoes that used to simulated barefoot state and its thickness of shoe sole was around 0.1 cm. Specific style of shoes was shown in Fig. 1.

Fig. 1. Shoes for experiment

2.2. Experimental method

1) Experiment on force plate of shoe sole

Twelve females in good health and with normal feet morphologic function and similar competitiveness were selected from professional aerobics team of the Physical Culture Institute. After technical training and preliminary experiment, movements

of those 12 athletes were stable. Thus, the measured data exhibited a high reliability. Those 12 athletes were divided into 3 groups with 4 people in each group. Emed measuring system was applied to measure indexes of plantar such as Mean force, PP, FT and MF (The maximum ground reactive force) when athletes in the three groups were walking on emed force plate wearing Huakang shoes, Reebok shoes and gymnastics shoes, respectively. Before formal experiment, preliminary experiment was conducted. In processing data, standard five-area partition was selected. Detailed standard five-area partition is shown in Fig. 2.

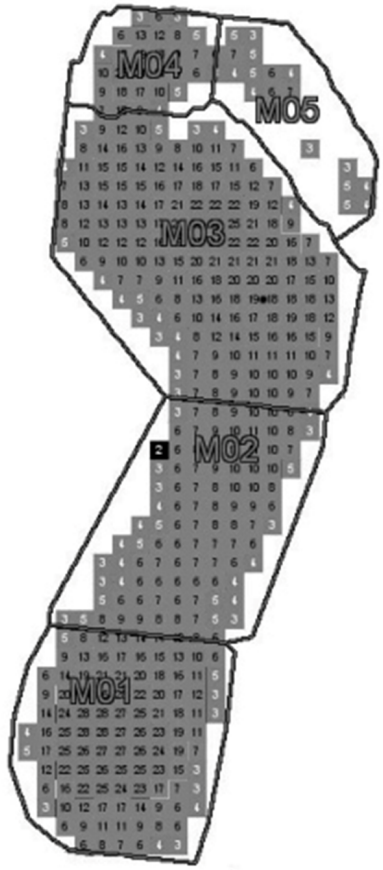

Fig. 2. Plantar-area partitioning

(2) Experiment on plantar pressure

Athletes in three groups wearing Huakang shoes, Reebok shoes and gymnastics shoes those with insole of force plate were required to complete specific aerobics lower limb movements in the set time, including knee lift jump, jumping jack and skip jump. Plantar pressure testing system of insole was used to record partial related mechanical parameter, such as Mean force value, PP value, MF value and FT value. Before formal experiment, preliminary experiment was conducted. All

data were analyzed by software "novel database essential". Besides, EXCEL 2003 and SPSS 12.0 statistical software were used for multivariate statistical analysis and statistical test.

3. Experimental results and analysis

3.1. Results and analysis of experiment on force plate of shoe sole

Four indexes of feet were tested with force plated and the results showed that there were no significant differences for the four indexes of feet. Thus, right foot data of those athletes in the three groups were selected from experiment results and analysis for further analysis. Kinetic parameter of different shoes and barefoot was tested and those data were compared in pairs, and specific results are shown in Table 1 and Table 2. It was shown in Table 1 that performance of Huakang shoes was better than that of Reebok shoes in terms of reducing movement FT and pressure. It was showed in Table 2 that there was a significant difference for Mean Force value of Reebok shoes and barefoot and of Huakang shoes and barefoot. However, there was no significant difference for kinetic parameter of three different kinds of shoes in terms of the other three indexes.

Table 1. Results analysis of kinetic parameter of walking with different kinds of shoes ($x \pm s$)

Shoes	Mean Force (N)	FT (N)	PP (N/cm^2)	MF (N)
Huakang	76.89±14.33	51.90±10.29	309.18±43.21	199.45±21.76
Reebok	80.27±13.63	60.61±19.28	313.54±32.29	258.33±73.61
Barefoot	112.38±23.65	73.63±15.17	501.32±187.25	282.67±37.90

Table 2. Difference comparison for kinetic parameters of walking with different kinds of shoes

Shoes	Mean Force (N)	FT (N)	PP (N/cm^2)	MF (N)
Huakang & Reebok	0.894	0.557	1.002	0.198
Reebok & Barefoot	0.012	0.442	0.114	0.811
Barefoot & Huakang	0.005	0.087	0.112	0.059

On "shoes-ground" surface, there was no significant difference for Mean Force and MF value of athletes in three groups wearing Huakang shoes and Reebok shoes and those values were lower than that of barefoot. It indicated that resultant force of ground cannot be changed by these two types of shoes, but Mean Force value and MF value can be lowered to a certain degree by using difference materials and structure to adjust component forces of plantar and material structure of shoes. In this case, Huakang shoes were better than Reebok shoes. Thus, it can be inferred

that there were no significant difference for active force on the ground of athletes in the three groups wearing those two kinds of shoes. Specifically, Huakang shoes can lower the maximum plantar pressure more than the Reebok shoes did. Thus, Huakang shoes were better than Reebok shoes in terms of reducing movement FT and pressure.

3.2. Results and analysis of experiment on plantar pressure

German insole plantar pressure measuring system was used for recording and difference comparing related mechanical parameters of partial plantar areas when experimental subjects were doing specific aerobics movements wearing different kinds of shoes and barefoot, and the results are shown in Table 3, Table 4 and Table 5, respectively. Data of those three tables show that for those three kinds of shoes, there were some differences but not significant among them for the four indexes. It can be inferred that Huakang shoes were better than Reebok shoes in reducing FT of the fore sole of feet, protecting feet and absorbing shock.

Table 3. Results analysis of jumping jack in different kinds of shoes ($x \pm s$)

Shoes	Mean Force (N)	FT (N)	PP (N/cm^2)	MF (N)
Huakang	148.09±42.78	207.48±88.53	418.79±83.47	352.36±102.69
Reebok	135.12±19.89	378.74±46.21	414.30±120.43	370.53±103.22
Barefoot	135.03±43.33	160.84±74.32	467.90±98.48	362.42±73.82

Table 4. Results analysis of knee lift jump ($x \pm s$)

Shoes	Mean Force (N)	FT (N)	PP (N/cm^2)	MF (N)
Huakang	145.53±46.18	156.37±198.45	374.97±94.03	328.54±132.88
Reebok	133.28±56.90	408.21±189.56	408.79±118.64	358.39±125.34
Barefoot	135.36±53.65	127.67±135.89	423.44±121.78	328.78±138.96

Table 5. Results analysis of skip jump ($x \pm s$)

Shoes	Mean Force (N)	FT (N)	PP (N/cm^2)	MF (N)
Huakang	151.53±56.09	435.61±134.37	401.53±150.02	263.34±132.74
Reebok	125.84±53.22	445.72±169.58	352.54±147.23	312.36±143.12
Barefoot	112.70±39.17	346.73±167.46	423.29±154.52	301.56±153.78

Research showed that plantar contacting area and pressure intensity of plantar areas were increasing with the increasing velocity of movement, thus, ground reactive force of plantar were increasing [7]. In jumping movement of aerobics, the fore sole

of feet played an important part in bearing. Two kinds of sports shoes studied were able be absorb shock of plantar to a different degree and reduce ground impact force for feet. Shock absorption principle was different, but generally, it was made up of shock absorption material and shock absorption structure. Mainly, the frequently used material of shock absorption for aerobics shoes is EVA material. With EVA material shoe sole, Huakang shoes are able to reduce body shock and absorb and reduce reactive force in order to protect feet.

4. Conclusion

Below two conclusions were drawn through experiment on force plate of shoe sole and on plantar pressure:

(1) Huakang shoes are better than Reebok shoes in terms of reducing movement FT and pressure.

(2) Experiments on plantar pressure shows that Huakang shoes are better than Reebok shoes in terms of reducing FT of the fore sole of feet and protecting feet.

These two experiments showed that high springback material is recommended for shoe sole of aerobics shoes because it can improve shock absorption performance. And shock absorption performance of material of the fore sole of feet should be improved when designing professional aerobics shoes.

References

[1] S. M. Abd Elkader, Y. N. Abd Elhafz, S. S. Al-Abdulrazaq: *Foot taping versus medical shoes on kinematic gait parameters in children with Down's syndrome.* World Applied Sciences Journal *27* (2013), No. 3, 311–317.

[2] M. Shieh, Y. E. Yeh: *A comparative study on perceptual evaluations of sports shoe exterior colors in Taiwan.* Color Research & Application *40* (2015), No. TOC. 2, 178 to 193.

[3] M. Héroux, I. Janssen, D. C. Lee, X. Sui, J. R. Hebert, S. N. Blair: *Clustering of unhealthy behaviors in the aerobics center longitudinal study.* Prevention Science *13* (2012), No. 2, 183-195.

[4] S. Zhang, K. Clowers, C. Kohstall, Y. J. Yu: *Effects of various midsole densities of basketball shoes on impact attenuation during landing activities.* Journal of Applied Biomechanics *21* (2005), No. 1, 3–17.

[5] E. M. Hennig: *The influence of soccer shoe design on player performance and injuries.* Research in Sports Medicine an International Journal *19* (2011), No. 3, 186–201.

[6] Q. E. Qiu, Q. L. Hu, Y. D. Gu: *Experimental study on mechanical properties of sole materials of aerobics sports shoes.* Advanced Materials Research *341–342* (2011), 77 to 79.

[7] K. Wörtler, C. Schäffeler: *Acute sports injuries and chronic overuse stress damage to the forefoot and midfoot.* Radiologe *55* (2015), No. 5, 417–423.

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