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Study of the Dynamics Characteristic on Pupils Walk with Heelys

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Abstract: To study the dynamics characteristics of primary school boys with Heelys. To analyze three different gaits of fifteen primary school boys walking with sneakers , closed-wheel Heelys (CWH) and open-wheel Heelys (OWH) using the German Novel Pedar-x plantar pressure test system. It showed that plantar pressure, peak pressure and impulse all increased gradually on forefoot area, they became smaller on midfoot and rearfoot with the increasing of heel height. Then the dynamics index existed significant differences ($P<0.05$) when pupils wore sneakers, CWH and OWH. It was suggested that pupils did not wear Heelys so long.

Keywords: Heelys; Sneakers; Dynamics characteristics

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1. Introduction

Along with the society's progress and the development of science and technology, the researchers designed shoes should not only meet physiological function, but also pay much attention to the fashion of shoes. The design of Heelys is reflected the students' desire to fashion, it is popular among the students in a short time.

Heelys is a pair of shoes, it likes either sneakers and ice skates shoes. Heelys has no different with ordinary sneakers in appearance, but there are single or double wheels in the heel [1]. The construct of the shoe is that the wearer can transition from walking to heeling by simply open the Heelys' wheels at any time. With the appearance and characteristics, Heelys have become extremely popular among children in China. There was gait changes of the related research wearing Heelys about adults in a laboratory [2]. Some scholars pointed out that because the pupils ankle muscles and bones are not fully developed, pupils wearing Heelys for a long time is likely to harmful their arch of foot growth, ankle strength and muscle coordination [3]. According to the report, there are some previous pupils have examined pediatric injuries related to the use of Heelys in other countries. However, there have been a few published reports of the biomechanical studies on these shoes [4]. The objective of this study is to describe the effects on dynamics characteristics in pupils wearing Heelys. This paper provides the basis for future of the Heelys to improve the Heelys design for the manufacturers and correctly choose the Heelys for parents.

2. Method

Fifteen boys in elementary school participated in this study. They are all lovers of Heelys and each of them has one or more year experience in Heelys. No one has a related injury history, foot deformity or abnormal gait. Their basic information is shown in Table 1. The sneaker and Heelys used in our study were bought in the market at random. Their basic informations are shown in Table 2 and Fig 1.

Figure 1. Shoes used in the experiment

This experiment used the Novel Pedar-X plantar pressure test system. Ask the objects to try on the sneakers, closed-wheel Heelys (CWH) and open-wheel Heelys (OWH) separately, testing dynamics parameters .It's required that subjects shouldn't have violent campaign before test and try on shoes random in a quiet environment test. Each test time interval is ordered for 20 minutes. Three dynamics data in one test were selected for analysis of Novel Database essential. It was using one-way analysis of variance by SPSS17.0 to compare if there is a difference of dynamics in the process of walking with different type of shoes. According to the corresponding relationship about the anatomical location of foot and insole sensors, we will divide into three areas of forefoot, midfoot and rearfoot. Through these three areas it will reflect the entire plantar pressure distribution information.

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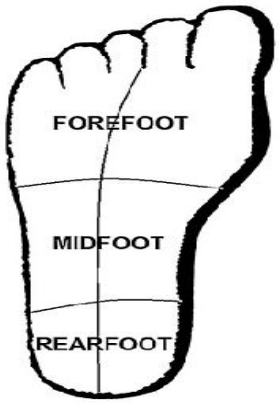

Figure 2. Foot zone distribution for plantar pressure analysis

This paper introduced the pressure / weight of the plantar pressure data of standardization of data processing in order to eliminate the weight of plantar pressure and the influence of different subjects results have certain comparability of data.

Table 1 Information of the subjects

Age	Height(cm)	Weight(kg)	Number
12.8±0.8	151.2±6.8	42.43±7.60	15

3. Results

Force is an important factor affecting the effect of exercise; plantar pressure refers to join force of each senior during test, plantar pressure test system can measure the plantar pressure of each area change over time. Based on analysis plantar pressure distribution of heelys, table 3 shows the difference between pupil walking with sneaker and walking with Heelys.

Table 2 Information of the shoes

Kind of shoes	Weight (kg)	Heel height (cm)
Sneaker	0.415kg	2.0
CWH	0.930kg	4.8
OWH	0.930kg	6.0

As we can see from Table 3，the plantar pressure of forefoot (a1) shows sneaker is bigger than CWH, and CWH is bigger than OWH. The plantar pressure of midfoot (a2) and heel (a3) show that sneaker is smaller than CWH, and CWH is smaller than OWH. There is very significant difference between sneaker and OWH. The different heel height of shoes may be the reason of these results. Each of the peak press measurement variables is found to contain significant differences between sneakers and Heelys, the test provides the peak pressure data of pupils wearing sneakers and Heelys (table 4).

Table 3 Plantar pressure data parameter of walking

Item	a 1	a 2	a 3
sneakers	74.75±25.27	35.25±22.82	282.37±62.96
CWH	80.30±35.08	18.74±16.56**	279.26±55.23
OWH	83.07±33.55**	11.72±12.89**	189.84±48.21**

Note: the statistical analysis between sneakers and Heelys, ** indicates the significance level $p<0.01$ and * indicates the significance level $p<0.05$.

In the forefoot, the order of the peak pressure is that OWH is bigger than CWH, and CWH is bigger than sneakers. In the midfoot and rearfoot, the order of the peak pressure shows an opposite result with forefoot. Plantar peak pressure is consistent with trend of change of the corresponding regional pressure, showing a statistical difference from walking with sneakers and OWH.

We use average impulse to reflect the variation of external force on feet in a period of time. The results of the plantar impulse changes distribution are displayed in table 5.

Table 4 Peak pressure data parameter of walking ($\bar{x}$ ±s)

Item	a1	a 2	a 3
sneakers	117.76±36.04	43.51±14.06	169.94±37.89
CWH	128.96±49.13	35.06±20.48**	159.08±29.98
OWH	139.47±45.71*	23.84±19.72**	110.95±28.76**

Note: the statistical analysis between sneakers and Heelys, ** indicates the significance level $p<0.01$ and * indicates the significance level $p<0.05$.

Impulse changes in the different regions of a foot. Impulse changes increase gradually on the forefoot, but they become gradually smaller and smaller on the midfoot and rearfoot. Each of the impulse variables is found to contain significant differences between sneakers and Heelys.

Table 5 Impulse data parameter of walking ($\bar{x}$ ±s)

Item	a1	a2	a 3
sneakers	11.37±5.66	6.39±5.48	40.96±14.89
CWH	13.53±7.14**	3.31±3.84**	40.20±12.38
OWH	18.26±8.97**	1.76±2.46**	24.07±10.56**

Note: the statistical analysis between sneakers and Heelys, ** indicates the significance level $p<0.01$ and * indicates the significance level $p<0.05$.

4. Discussion

Walking is a cyclical movement which single foot support and two-foot support alternating each other，generally we consider one foot left the ground and its landing as an cycle，it can be divided into three

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phase ： push phase，swing phase and landing buffer phase. Subjects' shoes always contact with the plantar pressure distribution during walking. Based on analysis plantar pressure distribution of Heelys, we can analysis its features and evaluation the risk of pupil wear Heelys in deeper level.

During walking subjects lifting heel passively, body mass center moved forward and plantar pressure gradually moved forward and led to the gradual reduction of planter pressure to the heel and the gradual increase of plantar pressure to forefoot [5-7]. For the bone structure，the classical theory of three point load suggest: because of the existence of longitudinal arch and transverse arch, heel, first metatarsal and the fifth metatarsal as the three point to

Bear load. Experimental data shows the heel height of CWH is 4.8 cm OWH is 6 cm, when pupils walk with heelys their body mass center move forward though longitudinal arch that make the pressure center and the body mass center moved forward, the pressure of heel decreased and the pressure of forefoot increased. The weight of heelys is 0.93 kg which is twice of sneaker, when foot frequently step the ground, the ground pressure and ground reaction force impact metatarsal again and again，foot muscles have been repeatedly pulled which made the periosteum stripping and cause metatarsal fatigue periostitis. The repeatedly pull cause periosteum and soft tissue around vessels gradually narrow and obstruction, tissue edema, metatarsal decalcified, the surrounding soft tissue over fatigue，metatarsal will lose it's support and protect functions, these will cause fatigue fracture. Many studies have shown that impact force associated with chronic injure [6], mainly included cartilage and ligament damage, impact force not only affect the foot and lower limbs but also has very close relationship with the lower back injure, even associated with the nervous system diseases.

Previously published reports described acute injuries using Heelys. When Foot site under too much pressure, it will abnormal high pressure peak and influence of foot structure and function. This case study of dynamics characteristics may have implications for potential overuse injuries.

According to the toe anatomy, the physiological function of metatarsus and phalanges slippery bursa is separated and reduces the friction between the broken metatarsal bones [9]. While increasing of pressure in the forefoot, slippery bursa is easy to occur due to squeeze and strain, and gradually produce inflammation. Foot pressure is gradually moved forward with the increase of heel height. Peak pressure becomes smaller and smaller on the rearfoot. Part of main impact load is display on the forefoot. It is show that the part of foot is easy fatigue and damage while elementary school students are walking. So Pupils should reduce the Heelys in time, and shouldn't wear Heelys as sneakers.

After analyzing the impulse, Forefoot impulse becomes increases with the heel height .it is the largest on the rearfoot, impulse on the forefoot is bigger than midfoot. It is instructions the arch has certain buffer function. It can control the balance and keep normal gait when walking.

Pupils may increase the burden of waist and back muscle wearing heelys. It is easy to produce irreversible damage on the knee and spine. At the same time, the design of the sneakers and Heelys must pay attention to the impulse function in of the part of the foot, increase the elastic of sole material. It can a certain degree relax the foot muscles and prevent muscle injury while walking.

5. Conclussions

Plantar pressure, peak pressure and impulse mainly concentrated on rearfoot when the pupils walk with sneakers, closed-wheel Heelys (CWH) and open-wheel Heelys (OWH). Foot pressure is gradually moved forward with the increasing of heel height. Plantar pressure, peak pressure and impulse become smaller and smaller on the rearfoot but they become increasing gradually on forefoot. It exists significant differences of plantar pressure, peak pressure and impulse when pupils wear sneakers, CWH and OWH. Pupils in the still growth should not wear Heelys for a long time in order to avoid tendon injury in foot.

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