

Study on the Influencing Factors on Comfort of Children's Shoes

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Abstract

The comfort of shoes is especially important for children whose feet are in the period of growth and development. However, many children's shoes on the market are too adult, or even an adult shoes shrink version. Whereas their morphologies are quite different, such shoes not only can not offer appropriate wear comfort for children but also hinder the healthy development of their foot. In addition, the distinction of children foot in different age groups is also very obvious. This paper mainly analyzes the foot characteristics of children in different age stages, such as foot morphologies, skeletal development and gait, summarizes the factors that affect the comfort of children's shoes, and provides some suggestions for the purchase of children's footwear.

Keywords: Children, Shoes, Foot morphologies, Comfort, Factors

1. Introduction

According to the sixth national census data, China's population aged 0-14 is about 222 million, accounting for about 16.60% of the total population (National Bureau of Statistics of the People 's Republic of China, 2011), this data shows that children's products are in a huge market space. The implementation of the Two-Child Policy has further expanded the child market, children's shoes as an important part of children's products, its R & D design has become the focus of the development of the industry. Some new design thoughts of modern children's shoes has been raised(Sun,2016). However, the current development of children's shoes market in China is not optimistic, the leading position in this market are mostly of foreign brands. On the basis of authoritative statistics, the domestic independent children's shoes brand in the entire children's shoes market accounted for only 10%(Li, 2013). The low competitiveness of children's shoes reflects many problems in the design, research and development, production process and marketing strategy of children's shoes manufacturing industry in China (Zhou, 2012). Its essential cause is the quality of the product. Children's shoes is defined as a health care products in international brand (Zhang, 2011), which should pay more attention to its functionality and comfort. Children's shoes should be ergonomic in order to meet the needs of consumers. Fully understanding the foot shape and skeletal development of children at all stages has an important reference significance on the design of children's shoes. It also can help customers to choose the right shoes.

Although the children's shoes are designed for children, but the buyer is usually their parents. Many designers of children's shoes make the design of children's shoes too adult, even just a shrink version of adult shoes to cater to the aesthetic standards of parents (Wang et al, 2014). Such as imitating women high heels designed out of toe tip, narrow, high heel children sandals. These so-called popular styles, not only do not make children feel comfortable in the process of wearing, and may affect the normal development of children's footsteps (Zhang, 2016). A German study shows that 98% of babies are born with healthy feet, but 60% of adults have varying degrees of health problems, and even 12% adults need foot treatment (Kinz et al, 2015). According to a survey conducted by the Quanzhou Municipal Bureau of Science and Technology, abnormal arches in children accounted for 47% of the total number of investigations in Fujian province, and the proportion of girls with abnormal arches was wider than that of boys (Zhang et al, 2015). The emergence of these problems is due to children wearing inappropriate shoes during foot development period. Due to the lack of proper cognition and understanding of children's feet, the product can not meet the comfort requirements of the foot, and has a negative impact on the healthy development of children's feet. This paper mainly analyzes the foot characteristics of children in different age stages, such as foot morphologies, skeletal development and gait, So that enterprises and consumers can aware of the large difference between children's feet. Meanwhile, this paper summarizes the factors that affect the comfort of children's shoes, and provides

some suggestions for the purchase of children's footwear.

Good footwear design, along with correct and well-fitting shoes, is even more important in children than in adults. An ill-fitting shoe can impede normal foot development, which can alter an individual's base support for the rest of his or her life. To create a properly fitted shoe, the shape of the shoe must closely resemble the shape of the foot (Mauch et al, 2009). This means that differences between different populations should be taken into account (Mauch et al, 2008). This paper first introduces the foot characteristics of children at all ages, and then analyzes the factors that affect the comfort of children at all stages, as well as other factors independent of age. Finally, the purchase advice of children shoes at all ages are summarized. Meanwhile, it provides theoretical guidance for the design and production of children's shoes.

2. Method

The literature search was performed across a variety of databases encompassing publications within the years of 1980- 2017. The search strategy employed across the electronic databases is presented below: children's foot, foot morphologies, shoes, comfort, gait. With the data found, the factors affecting children's shoes was compiled.

3. Results

3.1 Foot Characteristics of Children Depending upon the Age

3.1.1 Newborns (0-1years)

The baby's feet are smooth and round. It's with great elasticity. The soles are facing each other. The arch is filled with a fat pad, which makes the foot keep flat. The baby's big toe is much longer than the adult's and often far away from other four toes, which makes it convenient to move up and down (Xu, 2015). The foot is in a natural state of growth. The baby has not yet begun to learn to stand and walk during this age, so the function of the foot does not show up. The bones, muscles and ligaments of the foot start to develop. The best state at this time is barefoot, giving the foot free space to grow healthily.

3.1.2 Infant (2-3Years)

The foot goes on a fast rate of growth during this two years with boys and girls, so the shoes needs to be changed every two or three months on average (Wenger et al,1983).The shape of the foot is characterized by a wide part of the toe and the five toes are basically flush. The height of the thumb and the first metatarsal joints is high, that means, the toes part is high. The instep height and the tarsal bone is relatively large, whereas the heel girth is the smallest during the whole development process, the calcaneus has not developed completely (Qiu, 2005). The ratio of forefoot width to foot length is larger than adult's (Kong, 1999). The high specific value of basic width and heel width emphasizes that the baby's feet are inverted triangle (Qiu et al, 2014). The inside of foot is relatively straight and flat and the subcutaneous fat is thick. There is a large part of organic in the foot bone but very little inorganic salt, so the elasticity of the foot bone is good. It's very soft and easy to be distorted (Li, 2003). Children start trying to stand and learning walk at the age of 2. Toddlers often have poor balance, they can not accurately grasp the height of the feet should be raised. Without the help of an adult, the children couldn't walk steadily. Therefore, to avoid wrestling, the two feet will be separated and the center of gravity will be moved down to improve the stability (Zhong, 2000). But this gait easily leads to knock kneed and strephexopodia (Wu et al, 2008). Children in this period are very active and have poor ability to control their behavior. They are easily injured during walking or exercise, and are not easily detected.

3.1.3 Early School Age(4-6Years)

At this stage, the fifth toe of the foot is slightly longer than others, the ball width becomes wider and wider, and the toes of the children are more evenly aligned than the adults'. Children's foot muscles, tendons and ligaments and other connective tissue strength has increased, to a certain extent, increased the stability of the foot. The arch begin to show up during the early school age and continue develop until puberty. Due to the insufficient strength of the foot muscles,the driving force of the leg swing is small and the ankle is weak and unstable, which can lead to foot disease and deformity of the foot. The excessive pressure of the arch can easily lead to flat feet, so this stage is also called the fragile growth period of the foot.

3.1.4 School Age (7-12Years)

As the foot grows, the fat gradually decreases, the metatarsal and phalanges tend to be parallel, and the fan shape of the forefoot is no longer obvious. At this age differences in the foot shape between boys and girls start to evolve. While girls have a slender, delicate foot, boys have a much more voluminous midfoot (Walther et al, 2008). Spanish

scholars have shown that: the ages at which most differences appeared between boys and girls were at 8-9 years and 9-10 years. These data suggest that boys' and girls' foot morphology starts to differ significantly at this age. The greatest differences between boys and girls of the same age were ball width, ball girth and instep height (Laura et al, 2014). Domestic survey data shows that the development of children's feet in the ages of 10-12 is quite different, and the maximum difference of foot length can reach up to 40mm. Although children have the same foot length, their ball girth and heel girth are in great difference. With the increase of age, the foot tends to be narrow and thin (Wu et al, 2017). This studies showed that significant differences of foot morphologies between sex and age appeared during school age. The coordination and balance capacity of their body improves greatly at this age, so walking, running, and climbing steps can be easily accomplished. They can walk with a fluency and regular pace, the step length usually remains a certain value (Chen, 2011). Children start going to school and attending some outdoor sport activities at this age. With the increasing frequency and growing intensity of outdoor activities, the volume of perspiration in foot increases. The sweat holds a lot of particles of organic matter. Then the organism will be decomposed under the effect of bacteria and its production is acidic, which can corrode the shoes and socks. This process releases pungent chemicals which affecting the sanitary property of interior shoes, causing physical discomfort and even leading a dermatophytosis (Xie, 2012). On the other hand, children's feet are in the period of skeletal calcification, the development of joints, muscles and ligaments. They are an important stage to form stable joints and powerful arches, and also a high incidence of foot deformities (Zhang et al, 2015). When children take strenuous exercises, the ankle can not bear the stress coming from the hard ground, which can lead to instability of the left and right foot and even cause a sprain in severe cases.

3.1.5 Adolescence (13-16Years)

The connective tissue of a teenager is almost mature. Their physical quality and athletic ability are as strong as that of an adult. Strong bones, well-developed muscles, and powerful ligaments and tendons are able to withstand stresses that increase with exercise intensity and load. However, bone integration and joint development continue in this stage and are still in relatively fragile growth (Zhang et al, 2010). The rapid increase in body weight and amount of exercise puts more stress on the feet. It requires more exercises to form strong foot muscles to support the arch.

3.2 Factors Affecting the Comfort of Children's Shoes Depending upon the Age

3.2.1 Newborns (0-1Years)

The foot growth rate of a newborn baby is particularly fast, and the foot bone morphology is not completely formed in this period, so shoes will affect the normal development of the foot bone at this stage, and the best state is bare feet. But considering the feet warm and preventing the baby's delicate skin from the external environment damage, the soft and comfortable socks can be considered as a substitute for the function of shoes. The baby's skin is about 1/10 of the thickness of adult skin, and lacks collagen fibers and sufficient elasticity, so it is easy to penetrate foreign objects and particularly sensitive to materials containing harmful chemical ingredients. The material selection of socks is particularly important, using the natural materials without stimulation and chemical additives are the best choices, such as natural colored cotton (Yuriy et al, 2013; Hao et al., 2013). Light color can make the baby's retina to be stimulated, and the natural colored cotton with low color brightness relatively meet this requirement. General colored fabrics, especially the colorful fabrics use a lot of coloring agents, will hurt your baby's delicate skin. A material with excellent air permeability and moisture permeability is helpful to keep the clean internal environment.

3.2.2 Infant (2-3Years)

Because child foot type is inverted triangle at this age, the shape of the shoe must closely resemble the shape of the foot to create a properly fitted shoe. so the toe part should be designed rounded, heel parts can be relatively narrow. Toddlers are constantly changing between crawling, standing and walking, so shoes are relatively soft to fit into 3 different ways of movement. Babies are encouraged to walk barefoot, letting the foot in direct contact with the ground, which can enhance the sense of foot grip and the ability of balance. So the sole need to be as thin as possible. Children may kick obstacles when learning to walk, the toe cap must have appropriate hardness to protect the toes. The speed of metabolism is very fast during infant stage, the volume of perspiration in foot increase corresponding. Therefore, the upper material should have good breathability and moisture permeability. Leather material is a nice choice. The foot is bent in the metatarsophalangeal part during walking, so the bending part of the sole should also be in accordance with the law in order to reduce the feeling of fatigue when walking. Meanwhile, the hard heel cup can help to control the valgus foot and stabilize the foot shape so that the foot can grow in a good environment.

3.2.3 Early School Age(4-6Years)

The toe part should also be designed rounded due to the foot shape. Ball width becomes wider in this age, so the fore

part of shoes should be broaden as well. The hard heel counter can stabilize the heel bone and improve the stability of walking. Furthermore, it also can promote the development of children's foot muscles and nerve endings to form a strong arch. The back height should be reasonable, which needs to be lower than the height of the inside and outside the ankle, so that it not only can benefit the activities of the ankle, but also protect the ankle from injury. It should be taken into consideration that the height of malleolus medialis is lower than the height of malleolus lateralis (Ma et al, 2008).

3.2.4 School Age (7-12Years)

At this stage, the foot shape between boys and girls have significant difference, and shoes should be selected according to their foot characteristics. It is important to know your own foot length and choose the right shoe size. Everyone has different forefoot size, that's why the wide and circumference of shoes are also vital factors to determine the comfort of footwear. With the growing intensity of sport activities, a pair of shoes with good absorption is even more important(Dinato et al, 2015). In addition, shoes should also provide the rear support, not only the main activity axis of the foot can be concentrated in the ankle joint, avoiding the appearance of excessive "O" or "X" legs of children, but also can relieve the burden of ligaments and muscles in the metatarsophalangeal joints.

3.2.5 Adolescence (13-16Years)

This stage shoes can be designed in accordance with adult shoes. But the shock absorption function of the sole is still necessary. Appropriate pressure can help bones and muscles develop, but if the pressure is too large, it is likely to cause damage. The shock absorption function is determined by the strength of the movement, the hardness of the surface and the condition of the individual. Running on these hard surfaces without cushioned shoes will lead to injuries and strains (Robbins et al,1989; Komi et al,1993). On the other hand too much cushioning can lead to problems in the neuromuscular transmission process and therefore cause sports related injuries (Stussi et al, 1992).

3.3 Factors Affecting the Comfort of Children's Shoes Independent of Age

3.3.1 Shoe Size

International studies have shown that more than 50% of children wear too small shoes. A group of researchers at the Vienna Medical University showed that 69% of Austria's children outdoor shoes are too small, the proportion of home shoes even up to 88%. The study on the Affiliated Hospital of the University of Tübingen in Germany has also yielded the same conclusion that 60% children's shoes in 2-4 years old are too small. A long-term wearing of small children's shoes easily lead to foot deformity, and may further affect the locomotor system. The main cause of this problem is that the children's foot nerve has not yet developed completely, the bones and muscles have poor perception, the feet do not feel any pain even if children wear the inappropriate shoes. The small shoes will squeeze the feet, which is not conducive to the natural development of the feet. Large size shoes not only affects the appearance, but also lead to unstable walking, swaying, or even twisted (Qiu, 2003). Therefore, it is necessary to ask the children's subjective feelings in the purchase of shoes, but also to follow certain scientific methods. Toe cap to tiptoe at least leaving a interspace of 10mm, 12mm is the best spacing.

3.3.2 Lightweight of Shoes

The weight of children's shoes is also an important factor affecting sports comfort, and it has a significant impact on physical energy consumption. Studies have shown that when the weight of shoes increases by 1%, people's physical energy consumption will increase by 3%~10%. The weight of shoes not only affect the the physical consumption , but also affect the level of fatigue. The heavier the shoes are, more tired the body feels and the less comfortable it is. Therefore, for the relatively large amount of exercise in middle childhood, it is very important to lightweight shoes materials (Ma et al, 2012).

4. Discussion

The foot shape of the children in each age group is different, so the comfort factors that affect the shoes are not the same. This article analyzes them one by one. Meanwhile, some suggestions have been given to choose the appropriate shoes according to ages.

Newborns: Bare feet is the best choice, or use socks instead of shoes. The material of socks requires softness, comfort, moisture absorption, breathability, safety and environmental protection. Cotton sock is the recommendation, and the color of socks should not be too bright.

Infant: Vamp should be soft and good breathability. Round toe part and loose shoe type makes the baby with shoes can also be as free as the bare feet. The sole should be light and easy to bend. Good skid resistance of sole is also

important.

Early school age: Shoe size need to be right. The counter should have appropriate hardness, whereas the uppers remain soft. The sole should have the appropriate thickness and hardness to enhance the stability of the ankle joint. The foot is bent in the metatarsophalangeal part during walking, so the bending part of the sole should also be in accordance with the law in order to reduce the feeling of fatigue when walking.

School age: The feet of the boys and girls are quite different, so shoes are selected according to the shape of the individual foot. Not only the length, but the width is very important to be appropriate. Excellent moisture permeability is necessary for shoes. In addition, it should take the cushioning of sole into account.

Adolescence: You can choose shoes as the adults do.

5. Conclusion

Children's foot are quite different from adults', so parents shouldn't choose shoes as their taste. The distinction of children foot in different age groups is also very obvious. Parents need pay attention to the change of their child's foot, which can help them choose the correct shoes. This paper has provided some suggestions on how to purchase shoes according to foot characters. The shortage of this article is that it does not make specific analysis according to the shoe category.

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