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Perspective Chapter: Improving Children's Foot Health and Shoe Education from the Foot Health Education Project

Satoshi Kojima, Tomoyuki Maruo and Tomoko Kawaguchi

Abstract

With the aim of improving the foot health of infants and school-age children, Kinjo University in Japan has established the *Foot Health Education Project* in 2014, under which university faculty members, students, and industrial organizations have conducted joint activities. The results of surveys on approximately 3000 children to date have shown high prevalence rates of bunions, undeveloped foot arch, floating toes, and a paucity of wearers of right-size shoes. Under such circumstances, a follow-up survey has been conducted to examine whether changes in foot morphology can be reversed by wearing right-size shoes. The results have suggested that wearing right-size shoes facilitated the development of foot arch and improved floating toes. We plan to continue surveys and share the trends obtained from survey results and possible measures with community residents. In addition, we plan to establish scientific evidence that is useful for education and that contributes to the healthy development of children's feet.

Keywords: children, shoes, foot arch, floating toes, shoes education

1. Introduction

Recent studies have reported various changes in the feet of infants and school-age children [1, 2]. Notable changes include hallux valgus, bunions [1, 2], floating toes, and undeveloped foot arch [3]. However, fact-finding surveys on different age groups have been lacking, whereas surveys on small populations in limited areas have been reported. Therefore, surveys to determine changes and their prevalence among children over time are required.

Much has remained unknown about the cause of these changes in foot morphology. Measures recommended for the proper development of the feet include playing outdoors [4], exercising with bare feet [5], and wearing shoes properly [2, 6]; however, these measures lack evidence. Therefore, elucidating the causes of such morphological changes and proposing specific measures for prevention and correction have become necessary.

To tackle these issues, Kinjo University in Japan has established the *Foot Health Education Project* in 2014 with the objective of improving the foot health of infants and school-age children. This joint project has been conducted by university faculty members, students, and industrial organizations toward the following goals:

- i. To survey foot-ground contact and toe deformities and share findings with children, guardians, and educators;
- ii. To increase children’s knowledge about and interest in their feet and provide them with useful knowledge, such as how to choose the right shoes, the proper way of wearing shoes, and how to acquire good exercise habits;
- iii. To accumulate data and present scientific evidence useful for education;
- iv. To widely disseminate trends and measures based on survey results to the community and academic societies; and
- v. To provide education on foot maintenance, how to select shoes, and how to wear shoes.

To date, this project has conducted fact-finding and annual surveys on approximately 3000 children. The subsequent text summarizes the findings from these surveys and discusses common changes in foot morphology among children and possible measures for prevention and relief.

2. Fact-finding surveys on children’s feet and shoes

This project has been conducting fact-finding surveys on feet and shoes in infants and school-age children since 2014. **Table 1** presents the incidence rates of abnormal findings among children aged 3–8-years. Hallux valgus (first metatarsophalangeal angle $\geq 16^\circ$) tended to increase from 6 years of age, whereas bunionette (digitus quintus angle $\geq 12^\circ$) was found to be highly prevalent among 3-, 6-, and 8-year-old children (approximately 40%, 50%, and 75%, respectively). Moreover, foot arches were not formed in approximately 40% of 8-year-old children (third grade in elementary school). Floating toes (i.e., toes are not in contact with the ground when standing) were common among children from an early age, where children with 10 toes touching the ground were fewer than those who did not [7]. A cross-sectional

		3 y/o (n = 566)	4 y/o (n = 545)	5 y/o (n = 560)	6 y/o (n = 274)	7 y/o (n = 266)	8 y/o (n = 150)
Hallux valgus	(%)	6.6	6.2	4.2	13.4	25.1	24.0
Bunionette	(%)	39.6	38.8	39.1	52.1	68.1	74.7
Undeveloped foot arch	(%)	50.6	49.2	37.0	42.1	39.2	39.3
Floating toes	(%)	65.4	63.6	63.3	68.8	76.7	79.3

Table 1.
Incidence rates of abnormal findings.

		Elementary school students (n = 119)	Middle school students (n = 44)	High school students (n = 160)
Hallux valgus angle	(°)	10.5 ± 5.4	12.0 ± 4.7	10.8 ± 5.1
Digitus quintus angle	(°)	13.6 ± 4.9	14.7 ± 4.7	15.2 ± 5.0*
Floating toes	(%)	68.1	75.0	78.1

*Tukey-Kramer test; vs. elementary school students, $p < 0.05$.

Table 2.
 Toes angles and floating toes in students.

survey [8] on elementary school, middle school, and high school students has demonstrated that the digitus quintus angle in high school students was greater than that in elementary school students. Moreover, the prevalence of floating toes increased with age by 68.1%, 75.0%, and 78.1% in elementary school, middle school, and high school students, respectively (**Table 2**). These fact-finding surveys have revealed that children today exhibited high prevalence rates of bunionette, undeveloped foot arch, and floating toes, which supported the findings from previous studies [9, 10].

Furthermore, a survey on the difference in size between feet and shoes was conducted on infants, elementary school students, middle school students, and high school students. **Table 3** summarizes the results. Japan Engineering Standards stipulated that shoe size indicates the foot length that can fit in the shoe; therefore, appropriate shoe size should be equal to the foot length. A survey on measured foot lengths and shoe sizes revealed that 48.0% and 23.5% of infants and elementary school students, respectively, and 10% of middle school and high school students were wearing right-size shoes, whereas older children tended to wear shoes larger than the right ones [7, 8]. When guardians, middle school students, and high school students were asked about the reason for purchasing particular shoe sizes, their most common responses were: “did not know what the right size was,” “intentionally selected a larger size given the further growth of the feet,” and “thought the purchased one was the right size.”

These results indicated that people tended to purchase oversized shoes due to a misunderstanding of the right shoe size; the assumption that loose-fitting shoes are the right size; or an overestimation of the growth speed of children's feet. In Japan, no opportunities practically exist to measure the size of feet, such that many people are unaware of the size of their feet. Thus, people must rely on how the shoes feel when putting on shoes or have children put on their shoes to determine the appropriate size. Moreover, opportunities to learn about shoes in Japan are lacking, and the Japanese shoes

		Infants (n = 952)	Elementary school students (n = 119)	Middle school students (n = 44)	High school students (n = 160)
Undersized shoes	(%)	5.2	2.5	0	0
Right size	(%)	48.0	23.5	2.3	7.5
Oversized shoes	(%)	46.9	73.9	97.7	92.5

Table 3.
 Size difference between feet and shoes.

		Right size	Inappropriate-size	p value
		(n = 308)	(n = 321)	
Percentage	(%)	49.0	51.0	—
Hallux valgus	(%)	6.7	4.7	0.14
Bunionette	(%)	33.5	38.2	<0.05
Undeveloped foot arch	(%)	44.5	48.6	0.16
Floating toes	(%)	52.6	74.5	<0.05

Chi-square test.

Table 4.
Changes in foot morphology by shoe size.

culture prefers shoes that are easy to wear and remove [11, 12]. These examples are a few of the reasons why children and their guardians fail to select appropriate shoe sizes.

3. Impact of inappropriate shoe size on feet

Changes caused by wearing inappropriate shoe size constantly include hallux valgus, bunionette, and keratosis of the skin, such as calluses [13, 14]. Especially, many studies reported a correlation between keratosis and pain [15]. Interestingly, several studies observed that complaints about pain are more common in people wearing oversized shoes than in those wearing undersized shoes [16].

In terms of morphological changes related to the toes, bunionette and floating toes were frequently observed in individuals wearing inappropriate-size (oversized) shoes than in those wearing appropriate-size shoes (Table 4) [17]. Thus, the constant use of oversized shoes is likely to promote toe deformities and injuries in addition to other risks of wearing shoes [18, 19].

4. Right-size shoes help the feet to fulfill their function

This project conducted a one-year follow-up study to examine whether the use of appropriate-size shoes alleviated the changes in foot morphology [20, 21]. We provided 120 students (n = 35, 17, 17, 25, and 26 in 1st, 7th, 8th, 10th, and 11th grades, respectively) with shoes fitted to their foot lengths and widths. The students were requested to wear them as indoor shoes in their schools for 1 year. The result indicated significant increases in the arch-height ratio (the height from the floor to the navicular bone/foot length) and significant decreases in the number of floating toes (Table 5). These findings suggested that using right-size shoes facilitates foot arch development, improves floating toes, and helps toes to fulfill their original function.

5. Shoes education for children

In Europe, people are accustomed to selecting the right-size shoes and wearing them properly to protect foot health [12]. As previously described, no such custom

		Elementary school students (n = 35)		Middle school students (n = 34)		High school students (n = 51)	
		First time	After 1 year	First time	After 1 year	First time	After 1 year
Arch-height ratio	(%)	9.6 ± 5.2	13.6 ± 8.0	12.4 ± 3.5	13.7 ± 3.1	11.8 ± 2.7	12.6 ± 3.4 ^a
Percentage of floating toes	(%)	77.1	68.6	70.6	55.9	84.3	52.9
Total number of floating toes	(Number)	92	67 ^b	71	34 ^b	103	41 ^b

^aChi-square test; $p < 0.01$.
^bPaired t-test; vs. first time, $p < 0.05$.

Table 5.
 Changes in arch-height ratio and floating toe at 1 year follow-up.

exists in Japan, such that selecting appropriate shoes is difficult for many Japanese people due to the lack of awareness about their foot size.

This project conducted a two-year longitudinal study on five-year-old children to examine the educational effects of providing knowledge on feet and shoes, how to select right-size shoes, and how to wear them properly [22]. However, the study observed no notable differences in the fitness of shoe size and changes in foot morphology. The results suggested that education should be initiated as soon as children are beginning to wear shoes. Moreover, education on how to wear shoes, instead of the size of shoes and whether shoes have any strap, was more influential among pre-school children. Thus, future studies should continue the education on the proper selection and wearing of shoes. Furthermore, an assessment of educational effects should be conducted.

6. Conclusions

In this project, we surveyed the common changes in the foot morphology of children and shared the trends observed from the results. We also presented possible measures to community residents. We plan to continue surveys and hope to characterize the effects of selecting appropriate shoes and wearing shoes properly on foot development. In addition, the fact remains that various foot changes are occurring in children today as demonstrated by previous studies and the surveys in this project. Despite these individual differences, we hope to build scientific evidence useful for education toward the healthy development of children's feet.

Conflict of interest

The authors received 213 pairs of educational shoes from the Japan Education Shoes in 2017 and 2018. There is no conflict of interest to be disclosed for other studies.

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