THE EFFECTS OF SHOE SUITABILITY ON PLANTAR PRESSURE DISTRIBUTION AND BALANCE PARAMETERS IN CHILDREN WITH HEARING IMPAIRMENT

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ORIGINAL ARTICLE

ABSTRACT

Purpose: The aim of this study was to investigate whether the characteristics of the shoes used by the children have an effect on the dynamic and static plantar pressure distribution parameters and balance parameters in hearing impaired children, and to compare the results with those of non-hearing-impaired children.

Methods: The study included 136 children, 68 children with hearing impairment and 68 children without hearing impairment. The Footwear Assessment Score (FAS) was applied to evaluate children's footwears. Flamingo Balance Test (FBT) was used to evaluate the static balance of the children, and the Functional Reach Test (FRT) was used to evaluate the dynamic balance of the children. Static and dynamic plantar pressure distribution measurements of the children were carried out with a sensored walking platform (Footscan® pedobarography system (RsScan-FootScan lab ltd., Ipswich, England)).

Results: In hearing impaired children, a positive relationship was found between FAS and dominant foot total percentage of pressure values. In children without hearing impairment, there was a negative relationship between FAS and dominant hindfoot pressure, and a positive relationship between FAS and anterior non-dominant foot pressure ($p<0.05$). There was no significant relationship of FAS with balance tests, dynamic plantar pressure values, and walking parameters in both groups ($p>0.05$).

Conclusions: The increase in static loading with the footwear suitability on the dominant foot in hearing impaired children may be an indication that children with balance problems load more on the dominant foot in order to feel safer.

Key Words: Balance, Footwear, Hearing Impaired, Plantar Pressure Distribution

İŞİTME ENGELLİ ÇOCUKLARDA AYAKKABI UYGUNLUĞUNUN AYAK TABAN BASINÇ DAĞILIMI, DENGE VE YÜRÜME FONKSİYONU ÜZERİNE ETKİSİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Bu çalışmanın amacı, işitme engelli çocuklarda çocukların kullanmış olduğu ayakkabılara ait özelliklerin dinamik ve statik plantar basınç dağılım parametreleri ve denge parametreleri üzerine etkisinin olup olmadığını araştırmak ve işitme engeli olmayan çocuklarla karşılaştırmaktı.

Yöntem: Çalışmaya 68 işitme engelli ve 68 sağlıklı olmak üzere toplam 136 çocuk dahil edildi. Çocukların ayakkabılarını değerlendirmek amacıyla Ayakkabı Uygunluğu Değerlendirme Formu (AUDF) uygulandı. Çocukların statik dengesini değerlendirmek için Flamingo Denge Testi (FDT), dinamik dengesini değerlendirmek için Fonksiyonel Uzanma Testi (FUT) kullanıldı. Çocukların statik ve dinamik ayak tabanı basınç dağılım ölçümleri sensörlü yürüyüş platformu (Footscan® pedobarografi sistemi (RsScan-FootScan lab ltd., Ipswich, England)) ile gerçekleştirildi.

Sonuçlar: İşitme engelli çocuklarda dominant ayağa ait AUDF ile toplam yüklenme oranı değerleri arasında pozitif ilişki; sağlıklı çocuklarda ise dominant ayağa ait AUDF ile ayağın arka bölümüne yapılan yüklenme oranı arasında negatif ve non-dominant ayağa ait AUDF ile ayağın ön bölümüne yapılan yüklenme oranı değerleri ile arasında pozitif ilişki olduğu gözlemlendi ($p<0,05$). Her iki grupta AUDF ile denge testleri, dinamik ayak taban basınç değerleri, yürüme parametreleri arasında anlamlı ilişki bulunmadı ($p>0,05$).

Tartışma: İşitme engelli çocuklarda ayakkabı uygunluğunun dominant ayakta statik yüklenme oranı ile artış göstermesi denge problemi olan çocukların kendilerini daha güvende hissetmek için dominant ayağa daha fazla oranda yüklendiklerinin bir göstergesi olabilir.

Anahtar Kelimeler: Denge, Ayakkabı, İşitme Engelli, Taban Basınç Dağılımı.

INTRODUCTION

The hearing system has three main components: outer, middle and inner ear. The outer ear collects sound waves and channels them to the ear canal. The middle ear converts sound waves into mechanical motion, and the inner ear converts this into electrical energy (nerve impulses). Various pathologies may affect one or more of these structures, causing hearing loss (1). Bilateral permanent childhood hearing impairment affects approximately 1 to 1.3 of every 1000 live births (2).

In children with hearing impairment, there is a lack of sensory organization in postural control. Balance and coordination disorders can be seen in hearing impaired individuals due to the impaired sensory feedback mechanisms (3). Balance is the ability to control the body's position in space for stabilization and orientation in a certain direction (4). Human balance is achieved through a multi-sensory process involving the visual, somatosensory, vestibular, and cerebellar systems. The anatomical and functional integrity of the vestibular system in the inner ear is essential for maintaining balance (5). Vestibular receptors receive stimuli regarding the position of the head in space and produce reflexes playing important roles in basic motor responses (6). However, when the information received from one of the sensory systems is limited (e.g., due to hearing loss), the perception of the spatial position of the body part may be affected, which may decrease postural control (7). Vestibular problems affect many areas of children's development, including static and dynamic balance reactions, coordination, and movement speed (8).

The foot provides balance and support while standing and stabilizes the body during walking. It is the only body part functioning on the outer surface (9). Therefore, footwears have been developed to protect the foot. Footwears are primarily used to protect the foot from injuries caused by uneven floor surfaces and excessive impact due to hard floors, and thereby infection and deformity. As civilizations developed, footwears have also become a fashion-determining product. However, footwear components supporting the foot are often overlooked for the sake of fashion. Footwears should protect the foot, increase friction and stability, absorb shocks, and prevent foot deformities. Choosing the most suitable footwears has a long history and especially the selection of children's footwears is very important (10). However, choosing the appropriate footwear remains a challenge for many people (both clinicians and parents) (11). Footwears are very important for hearing impaired individuals as well as for all children. To our knowledge, no study has been found in the literature examining the effect of shoe properties on balance and plantar pressure distribution in hearing impaired individuals.

The study aimed to investigate whether the effects of footwear properties on the plantar pressure distribution, which can be measured statically and dynamically, and balance parameters are different in hearing impaired children compared to those without hearing impairment.

METHODS

Subjects

The study included 136 children aged 6-18 years: 68 children with hearing impairment attending a state school for the hearing impaired in Ankara and 68 children without hearing impairment attending various state schools. The Gpower 3.1 program was used to determine the number of individuals to be included in the study. During the calculation, it was considered that the relationship between shoe fit and plantar pressure distribution would be at least low-medium level, and the correlation value was taken as r=0.350. When the H0 correlation level was taken as r=0 and power analysis was performed, it was determined that the number of cases that should be included in the study should be 61. A loss of approximately 10% that may occur during the study was taken into account, and the study was completed with 68 individuals. An equal number of individuals were also included in the control group (12). This study was designed as a case-control study. The children were recruited from April to May 2019. Children were divided into two groups as hearing impaired children and those without hearing impairment. In order to conduct our study, permission was obtained from the Ethics

Committee of Hacettepe University (GO 19/1081). Prior to the study, an informed consent form was obtained from the children's families, and the children consented verbally that they volunteered to participate in the study.

In our study, hearing impaired and non-hearing-impaired children who were cooperative and did not have an additional disease affecting the foot and ankle were included in the groups.

Outcome Measures

Demographic information (age, gender, dominant extremity, presence of additional disabilities), height, body weight, and body mass index (BMI) of all children participating in the study were recorded. The types of footwears used by the children were inquired, and their footwear fit was evaluated with the Footwear Assessment Score (FAS). The dynamic balance of the children was evaluated with the Functional Reach Test (FRT) and their static balance was evaluated with the Flamingo Balance Test (FBT). Static and dynamic plantar pressure distributions obtained during static stance and walking were assessed using the pedobarographic analysis method.

Evaluation of Footwear Style and Appropriateness

The FAS was used as an objective method for evaluating footwears. The reliability study of the Turkish FAS was conducted by Yakut et al. (13). The FAS is a valid and reliable scale designed to provide a comprehensive assessment of the footwear and can be effectively applied in clinical/research settings. All categorical items of the FAS are recommended for clinical evaluation of footwear in various populations (14). The highest total score for fit footwears is 15. Higher scores indicate that the footwear is suitable, and lower scores indicate that the footwear is not suitable (15).

Evaluation of Dynamic Balance

The Functional Reach Test (FRT), which was developed to assess balance problems rapidly and its reliability was established by Donahoe et al., was used to evaluate the dynamic balance of children (16). Longer reached distance in this test indicates better balance (17).

Evaluation of Static Balance

The Flamingo Balance Test (FBT) is a Eurofit test used in balance assessment with high reliability and validity, and it is simple, low-cost, and suitable for research in large populations. It is used to evaluate the ability to successfully maintain balance on one leg. To perform the test, only a stopwatch and a narrow balance board with a non-slip surface are required. The number of times the child's balance got disturbed during 60 seconds was recorded. If there was more than 15 falls/ balance losses in the first 30 seconds, the test was terminated (18).

Evaluation of Plantar Pressure Distribution

The examination of the foot plantar pressure distribution between the foot and the support surface where the foot touches is defined as pedobarographic analysis (19). The basic principle in pedobarographic analysis is to map the plantar surface pressure, which indirectly indicates significant postural abnormalities (20). Plantar pressure distribution measurements have the potential to objectively evaluate the effects of clinical practices on foot/ankle function (21). In our study, FootScan® (RsScan-FootScan lab ltd., Ipswich, England) sensor, a walking platform with a 1 m length (this was a limitation for our study), was used for pedobarographic measurements. In static measurements the peak pressures of both feet (N/cm^2), the percentage of pressure on each of the dominant and non-dominant foot (%), and the percentage of pressure on the forefoot and hindfoot (%) of both feet were recorded.

During the dynamic measurement, they were asked to look forward, not focus on the ground, and walk on the platform in the same way they normally walk. They walked five times and measurements were recorded. In dynamic measurements: foot axis angles, maximum and minimum subtalar joint angle values, force (N) and the maximum pressure (N/cm^2) under the 1st-5th fingers, 1st-5th metatarsal, midfoot, and heel medial and heel lateral; foot lengths and foot widths (cm); walking speed (m/second); and step length (cm) were recorded.

What kind of changes footwear causes in foot biomechanics/balance was assessed. We evaluated footwears that children wear frequently. A child can

Table 1: Descriptive Statistics of The Individuals' Demographic Characteristics.

Variables	Hearing-Impaired		Non-Hearing-Impaired			
	Minimum – Maximum	Mean±SD	Minimum – Maximum	Mean±SD	t	p
Age (year)	7 – 15	12.00 ± 2.44	7 – 16	12.69 ± 2.22	-1.728	0.091
Height (cm)	110 – 185	142.29 ± 14.85	146 – 180	159.99 ± 8.76	-8.459	0.012*
Body Weight (kg)	17.40 – 74.60	39.79 ± 14.40	30 – 84	51.47 ± 10.90	-5.335	0.010*
BMI (kg/m²)	12.82 – 33.16	19.03 ± 4.12	13.88 – 32.39	20.00 ± 3.47	-1.496	0.139

*p<0.05. BMI: Body Mass Index, SD: The Standard Deviation.

have very different footwears. All pedobarographic evaluations and static and dynamic balance measurements were performed barefoot.

Statistical Analyses

IBM SPSS 21.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Demographic characteristics are expressed as means, standard deviations, and min-max values.

The data were normally distributed. Therefore, normally distributed continuous variables of the groups were compared with independent samples t-test. The Chi-square test was used for categorical variables. Pearson correlation coefficient was calculated to determine the relationship between FAS total scores and static foot pressure distribution parameters, FBT, and FRT values by groups. A p-value of <0.05 was considered statistically significant.

RESULTS

Descriptive data of all 136 children, 68 children with hearing impairment and 68 children without

Table 2: A Comparison of Right and Left Shoe FAS Sub-Scores in Children with and without Hearing Impairment.

Variables for Right Shoe (Dominant Foot) n		Hearing-Impaired		Non-Hearing-Impaired		p
		%	n	%		
Material-Upper	**Leather**	38	55.88	26	38.23	0.042*
	Other	30	44.12	42	61.77	
Material-Outsole	**Syntetic/Rubber**	65	95.58	68	100	0.124
	Other	3	4.42	-	-	
Heel to Ball Length	**Fit**	66	97.05	68	100	0.148
	Not Fit	2	2.95	-	-	
Width of The Shoe	**Fit**	67	98.52	68	100	0.321
	Not Fit	1	1.48	-	-	
Available Room in The Toe Box	**Pinchable**	51	75	36	52.94	0.011*
	Not Pinchable	17	25	32	47.06	
Status of Keeping the Feet in Shoes	**Shoes Slide Off**	31	45.58	34	50	0.609
	Shoes Not Slide Off	37	54.42	34	50	
Heel Height	**> 2.5 cm**	28	41.17	38	55.88	0.049*
	< 2.5 cm	40	58.83	30	44.12	
Shoe Style	**Shoes or Slipper**	5	7.35	1	1.47	0.102
	Boot	3	4.41	-	-	
	Shoes or Boots With A Strap or Lace	60	88.24	67	98.53	

Heel Wear	**>5 mm**	7	10.29	4	5.88	0.348
	<5 mm	61	89.71	64	94.12	
The Length Available for Growth	**0 – 5 mm**	48	70.58	37	54.41	0.151
	6 – 11 mm	13	19.11	20	29.41	
	11 – 20 mm	7	10.31	11	16.18	
Variables for Left Shoe (Non-Dominant Foot)		**Hearing-Impaired**		**Non-Hearing-Impaired**		**p**
		n	**%**	**n**	**%**	
Material-Upper	**Leather**	38	55.88	26	38.23	0.042*
	Other	30	44.12	42	61.77	
Material-Outsole	**Syntetic/Rubber**	65	95.58	68	100	0.124
	Other	3	4.42	-	-	
Heel To Ball Length	**Fit**	66	97.05	68	100	0.148
	Not Fit	2	2.95	-	-	
Width of The Shoe	**Fit**	67	98.52	68	100	0.321
	Not Fit	1	1.48	-	-	
Available Room in The Toe Box	**Pinchable**	50	73.52	37	54.42	0.020*
	Not Pinchable	18	26.48	31	45.58	
Status of Keeping The Feet in Shoes	**Shoes Slide Off**	31	45.58	33	48.52	0.733
	Shoes Not Slide Off	37	54.42	35	51.48	
Heel Height	**> 2.5 cm**	28	41.17	38	55.88	0.049*
	< 2.5 cm	40	58.83	30	44.12	
Shoe Style	**Shoes or Slipper**	5	7.35	1	1.47	0.102
	Boot	3	4.41	-	-	
	Shoes or Boots With A Strap or Lace	60	88.24	67	98.53	
Heel Wear	**>5 mm**	7	10.29	4	5.88	0.348
	<5 mm	61	89.71	64	94.12	
The Length Available for Growth	**0 – 5 mm**	47	69.11	35	51.47	0.092
	6 – 11 mm	14	20.58	25	36.76	
	11 – 20 mm	7	10.31	8	11.77	

*p<0.05. MTP: The Metatarsophalangeal Joint.

hearing impairment, are given in Table 1. A comparison of the height (p=0.012) and body weight (p=0.010) of the participants showed a significant difference, but no statistically significant difference was observed in terms of BMI (p=0.139) and age (p=0.091).

In hearing impaired children, 85.2% of those with hearing impairment preferred sports footwears; 2.9% leather-soled footwears; 7.4% rubber-soled footwears; 1.5% boots with thick soles; 1.5% boots with plastic/rubber sole, and 1.5% used other style footwears. Regarding those with non-hearing-impairment, 91.2% preferred sports footwears; 2.9% boots with thick soles; 1.5% boots with plastic/rubber sole, and 4.4% other style footwears.

The comparison results of the FAS sub-scores belonging to the dominant and non-dominant footwears are given in Table 2. In the comparison of both groups, there was a statistically significant difference between the FAS sub-scores of the preferred material upper part (p=0.042), toe box height (dominant p=0.011; non-dominant p=0.020) and heel height (p=0.039) for the dominant and non-dominant footwears. There was no significant relationship between other values (p>0.05).

There was no significant relationship between FAS

Table 3: The Relationship between FAS Total Scores Obtained from Children with and without Hearing Impairment and Peak Pressures and Pressure Percentage Parameters (As Static Foot Pressure Distribution Parameters).

Variables	Hearing-Impaired				Non-Hearing-Impaired			
	FAS Total				FAS Total			
	Dominant		Non-Dominant		Dominant		Non-Dominant	
	r	p	r	p	r	p	r	p
PP Total (%)	0.321	0.014*	-0.301	0.063	-0.231	0.059	0.224	0.073
PP Front (%)	0.998	0.404	-0.187	0.119	-0.104	0.980	0.302	0.011*
PP Back (%)	0.243	0.057	-0.173	0.174	-0.268	0.032*	-0.031	0.807
Peak Pressure (N/cm²)	0.198	0.988	-0.011	0.963	-0.150	0.219	-0.208	0.094

*p<0.05. Peak Pressure: The Maximum Amount of Pressure Measured at the Sole of the Foot, FAS Total: Total Footwear Assessment Score, PP Back: The Percentage of Pressure that Occurs in the Hindfoot, PP Front: The Percentage of Pressure that Occurs in the Forefoot, PP Total: The Percentage of the Total Pressure Occurring in the Dominant/Non-Dominant Foot Sole; N: Newton; cm²: Square Centimeter.

total scores and values of dynamic plantar pressure distribution measurements in both groups (p>0.05). There was a increasing in the percentage of total pressure (PP) in the dominant foot with the increase in footwear suitability in children with hearing impaired (r=0.321, p=0.014). In non-hearing-impaired children, while FAS total score increased, posterior PP values decreased in the dominant foot (r=-0.0268, p=0.032) and while FAS total score increased, anterior PP values increased in the non-dominant foot (r=0.302, p=0.011) (Table 3).

The mean FRT value was measured as 15.62±2.96 cm in those with hearing impairment and 31.62±6.77 cm in those without hearing impairment. The FBT results (numbers of fall) were found to be 8.23±5.02 for hearing impaired children, and 1.97±2.46 for non-hearing-impaired children. While there was a statistically significant difference between the balance test results (p=0.000), in terms of the FAS total scores there was no significant difference between the groups (right p=0.961, left p=0.923) (Table 4). However, there was no statistically significant relationship between FAS total scores and FBT (dominant r=-0.220, p=0.072 in children hearing impaired; dominant r=-0.018, p=0.885 in without hearing impairment) and FRT (dominant r=0.067, p=0.586; non-dominant r=0.074, p=0.547 in children hearing impaired; dominant r=-0.039, p=0.753; non-dominant r=-0.081, p=0.513 in without hearing impaired) values in both groups.

DISCUSSION

It was found that footwear fit had no effect on dynamic plantar pressure distribution, walking speed, stride length, and balance in children with hearing impairment, but there was a significant relationship between footwear fit and pressure percentage, one of the static plantar pressure distribution parameters.

Foot flexibility that children have during their development makes the size, shape, and design of the footwear important. These features support the view that external factors such as the choice of footwear may affect the structural development

Table 4: Comparison of FAS total score, FRT and FBT between groups

		Hearing-Impaired	Non-Hearing-Impaired	t	p
		Mean ± SD	Mean ± SD		
	FRT	15.62±2.96	31.62±6.77	-17.853	0.001*
	FBT	8.23±5.02	1.97±2.46	9.231	0.001*
Total Score of FAS	**Right (Dominant Foot)**	11.18±1.95	11.19±1.56	-0.049	0.961
	Left (Non-Dominant Foot)	11.18±1.96	11.21±1.53	-0.097	0.923

*p<0.001. FAS Total: Total Footwear Assessment Score, FRT: The Functional Reach Test, FBT: The Flamingo Balance Test.

and function of the foot, and may have an impact on foot health in the long term, but still this theory lacks scientific evidence (22).

In our study, it was observed that the groups were not homogeneously distributed in terms of height and body weight. However, since the groups consisted of subjects with height and body weight suitable for their age, no statistically significant difference was found between BMI values. FAS scores decreased due to the fact that most of the children had low socioeconomic levels, the footwears they used were large, and also because the girls preferred footwears with lower soles just to look good. On the other hand, the children's heels were not worn because they could change footwears frequently due to the ease of access to low-cost footwears, and many children (especially boys) prefer footwears with laces and high soles, such as sports footwears, and these two factors have led to an increase in FAS scores. However, the use of textile as a product material in sports footwears, which are used by individuals because they are trendy, and the fact that this material decreases the toe box height even more were the reasons for low FAS scores. For this reason, when the FAS scores of the groups were compared, a statistically significant difference was found between the material preferred in the upper part of the footwear, toe box height, and heel height sub-scores. On the other hand no statistically significant difference was found between total FAS scores of groups.

Foot plantar pressure distribution analysis allows clinicians and researchers to evaluate foot function; to diagnose children and adolescents with musculoskeletal disorders affecting walking and feet; to assess the severity of the deformity; and, to decide on treatment, and it is a valuable tool in documenting short- and long-term results (23). According to the present results, no relationship was found between footwear fit and dynamic foot plantar pressure in both groups. However, the static plantar pressure values showed that PP on the dominant foot, i.e., the loading amount, increased in children with hearing impairment with better footwear fit. In children without hearing impairment, the footwear fit increases PP in posterior dominant foot and anterior non-dominant foot. According to this result, it can be said that children with hearing impairment have a higher load on the dominant foot due to the feeling of fear and insecurity arising from loss of balance.

It was reported that optimal foot development can be achieved with a better optimal balance control (24). The normal values of FRT scores reported by Deshmukh et al. in children aged 6-12 years ranged from 22.7±3 cm to 37±4.4 cm (25). According to these data in our study, the FRT score was very low in children with hearing impairment. However, the number of children with hearing impairment who failed during FBT was significantly higher than those without hearing impairment. When we look at the norm values of the FBT test for the age group included in our study, it was shown that children without hearing impairment have 95% and those with hearing impairment have 70% balance success rate (26). According to both results, it is possible to say that the balance abilities of children with hearing impairment were worse than those without disabilities. Despite this, no significant relationship was found between footwear fit and balance in both groups.

The footwear is the primary interface between the individual and the surface, and therefore will contribute to how the ground reaction forces produced during walking affect both foot and ankle. In studies conducted on conventional footwears in healthy children, it was stated that footwears are the main external factor affecting the walking of children (27). Current literature shows that footwears affect gait parameters (28,29). However, studies on whether these effects are important in terms of function or how they affect foot health and foot development in the longer term have been conducted (30).

Footwears have made progress not only in protecting the foot, but also in improving walking or motor performance in certain environments, such as outdoor walking or even indoors (24). In our study, all patients were wearing closed toe footwears. Accordingly, based on the evaluation results, there was no statistically significant relationship between footwear fit and walking speed and step length data in both groups.

The impact of the footwear on the biomechanical interaction between the foot and the environment forms the basis of the hypothesis that footwears can have a long-term effect on foot function. In this context, inappropriate choices have also been reported to have a negative effect on long-term foot development and foot health (22). However, understanding the effect of footwears on foot development is difficult due to the difficulties in identifying the foot as a functional biomechanical unit throughout childhood. In addition, studies on the effects of footwears on children with hearing impairment are lacking in the literature.

Knowing more about the social dimensions of footwears and what they mean for children are important steps towards helping shape footwear designs and also making footwear recommendations meaningful in practice. As a prerequisite for effective practical discussions about footwear choices for children, understanding what factors affect parental purchasing practices is important to help clinicians understand how they affect current choices and determine how best to give age-appropriate footwear advice (30). Considering that there is a wide range of varieties in the footwear industry today and the child wants to choose footwears in accordance with their own taste and fashion as the age of the child grows, it becomes even more important to research which footwears are healthier. Moreover, it should not be overlooked that footwears are a critical factor in providing appropriate sensory input to the foot in children with hearing impairment, in whom an important function, balance, is affected.

According to the results of study, it was concluded that footwear fit had no effect on dynamic plantar pressure distribution, walking speed, stride length, and balance in children with hearing impairment, but there was a significant relationship between footwear fit and pressure percentage, one of the static plantar pressure distribution parameters. This relationship is in the form of an increase in a greater load on the dominant foot with increasing footwear fit. It can be concluded that the increase in the loading rate with appropriate footwears in hearing impaired children may be because fit footwears contribute to self-confidence, which makes them more active. Development of suitable children's footwears can contribute to taking precautions in childhood and thus preventing different problems that may occur not only in childhood but also in advanced ages in hearing impaired children, which may be useful for clinical practices. However, more studies are needed for this. In addition, studies in which the foot pressure distribution is measured in the footwear may help to clarify this issue more.

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