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Our experience in the podological analysis of children with motor disorders (20 cases)

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Introduction and Importance: Pediatric patients with neuromotor disorders frequently experience various podiatric conditions. The effectiveness and implications of treatments like orthotics and insoles in this demographic are not thoroughly understood, highlighting a significant gap in podiatric research and clinical practice.

Case Presentation: This observational study analyzed 20 pediatric patients with neuromotor disorders. The focus was on common foot conditions such as ingrown toenails and hyperhidrosis, and their association with treatments like orthotics, insoles, and surgical interventions like Achilles tendon lengthening.

Clinical Discussion: Statistical analysis using chi-square tests revealed significant associations. Notably, orthotic use was linked to a higher incidence of ingrown toenails ($\chi^2 = 5.69$, $p = 0.017$). In contrast, insole usage correlated with increased hyperhidrosis ($\chi^2 = 4.44$, $p = 0.035$).

Additionally, a significant tendency for orthotic use was observed in patients who underwent Achilles tendon lengthening ($\chi^2 = 8.15$, $p = 0.017$). The study also highlighted the prevalence of brittle nails and hyperkeratosis among the participants.

Conclusion: The findings emphasize the critical role of podiatrists in the management of foot conditions in pediatric neuromotor disorder patients. While interventions like orthotics are generally beneficial, they may also exacerbate or contribute to other conditions, necessitating regular and careful podiatric monitoring. The study advocates for future research with larger sample sizes and controlled study designs to further validate and expand upon these observations.

Key words: MOTOR NEURON DISEASES; PODIATRY; PATIENT; CHILD; FOOT DISEASE

INTRODUCTION

The role of the podiatrist (1), a healthcare profession that is often under-recognized, is crucial in the multidisciplinary approach to managing disabling conditions, particularly those of neurological origin in the pediatric population (2–7). The importance of podiatry, as a subspecialty within orthopedics, becomes even more pronounced when dealing with young patients, where the emphasis should be on prevention as a primary intervention, in line with ethical principles (8, 9). Podiatrists participate with assessment and diagnosis, orthotic management, foot care and monitoring, collaboration with multidisciplinary teams, education, and support. In this study, we explore the podiatric issues, often multiple in a single clinical case, encountered in children with neuromotor disorders. We consider delicate situations where a podiatrist may not be able to change the life of a child who, for example, walks with the aid of a brace, but can certainly alleviate pain by addressing hyperkeratosis (10), ingrown toenails (11), and phalangeal deformities. Additionally, the podiatrist can recommend the appropriate foot orthosis to modify any pathological gait patterns (12,13). This study was conducted at the Physical therapy Unit, where not only children with neurological conditions

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are treated, but also patients with orthopedic issues and other conditions. These pediatric patients, aged between 4 and 16 years, presented with various conditions that led to motor deficits and, consequently, podiatric problems. We observed the different podiatric pathologies specific for each patient, assessed the conservative treatments previously adopted, and proposed podiatric solutions where appropriate. The aim of this study is to describe the podiatric issues of the foot in children with neuromotor disorders. We seek to determine whether there is a correlation between neuromotor deficits and the onset of podiatric issues, and how frequently these issues occur within the examined case series.

METHODS

This research adopted an observational case series design, aiming to provide a comprehensive overview of podiatric issues in children with neuromotor disorders. By focusing on real-world clinical scenarios, this design allowed for a detailed examination of the specific podiatric challenges faced by this population and the interventions employed. The study population comprised 20 pediatric patients, aged between 4 and 16 years, who attended the pediatric physiatry outpatient clinic of the Hospital Orthopaedic. These patients were selected based on the presence of motor deficits that could potentially lead to podiatric problems. We ensured that the study captured a diverse range of neuromotor disorders and their associated podiatric issues.

The breakdown of the study population is as follows:

- **Cerebral Palsy (CP):** 9 subjects diagnosed with CP, a group of permanent movement disorders appearing in early childhood. These patients often exhibit gait abnormalities, muscle stiffness, and involuntary movements, all of which can contribute to podiatric challenges (14).
- **Idiopathic Toe-Walking (ITW):** 2 subjects who exhibited toe-walking without an identifiable cause. ITW can lead to issues such as muscle shortening, balance problems, and increased risk of tripping, necessitating podiatric intervention (15).
- **Genetic Syndromes:** 9 subjects diagnosed with genetic syndromes known to impact the musculoskeletal system. This group included patients with Marfan syndrome (16), characterized by elongated limbs and flexible joints, and Ehlers- Danlos syndrome (17), known for hypermobility and skin that can be easily bruised. Both conditions can lead to unique podiatric challenges.

For each patient, a detailed medical history was taken, focusing on previous podiatric interventions, current complaints, and any conservative treatments adopted. A thorough physical examination was conducted, emphasizing the foot and lower limb. The findings were documented, and appropriate podiatric solutions were proposed based on individual needs.

The study received approval from our institutional review board. All participants provided informed consent in accordance with our institution's data collection and disclosure policy. Further ethical review was deemed unnecessary as no personally identifiable information was collected or stored.

Participants were recruited from the pediatric physiatry outpatient clinic of the Hospital Orthopaedic. The recruitment process was initiated by identifying potential candidates based on their medical records, which highlighted the presence of neuromotor disorders. To ensure a comprehensive representation of the target population, the clinic's database was systematically screened for patients aged between 4 and 16 years with a diagnosis of cerebral palsy, idiopathic toe-walking, or specific genetic syndromes (Marfan syndrome, Ehlers-Danlos syndrome). Once potential participants were identified, the research team approached them (or their guardians) during their routine clinic visits. They were provided with detailed information about the study's objectives, procedures, potential benefits, and risks.

Inclusion Criteria:

- Pediatric patients aged between 4 and 16 years.
- Diagnosis of cerebral palsy, idiopathic toe-walking, or genetic syndromes (Marfan syndrome, Ehlers-Danlos syndrome).
- Presence of motor deficits leading to podiatric problems.
- Willingness to participate in the study and adhere to follow-up schedules.

Exclusion Criteria:

- Patients outside the age range of 4-16 years.
- Absence of neuromotor disorders.
- Previous surgical interventions related to the foot or lower limb within the past six months.
- Any contraindication to podiatric interventions.

The primary outcome of this study was to evaluate the prevalence, and nature of podiatric issues in children with neuromotor disorders.

The primary aim of the statistical analyses was to provide a comprehensive overview of the podiatric issues in the study population and to identify potential correlations between neuromotor disorders and specific podiatric problems.

Determination of the number and percentage of participants presenting with specific podiatric issues, such as hyperkeratosis, Ingrown toenail, foot deformities, etc. Break-

down of the study population based on primary diagnosis (e.g., cerebral palsy, idiopathic toe-walking, genetic syndromes) to understand the distribution of neuromotor disorders.

Chi-Square Test: Used to test the association between two categorical variables, such as the type of neuromotor disorder (cerebral palsy, idiopathic toe-walking, genetic syndromes) and the presence of specific podiatric issues. It determines if the observed frequencies of occurrences differ significantly from what would be expected under the assumption of independence.

This study analyzed the foot conditions and treatments of 20 pediatric patients with neuromotor disorders. Associations between conditions like ingrown toenails, hyperhidrosis, and treatments such as orthotics, insoles, and surgical interventions were statistically evaluated using chi-square tests. The work has been reported in line with the PROCESS[18] criteria to ensure comprehensive and transparent reporting of this observational study.

RESULTS

The study encompassed a diverse group of participants (Table 1), with an average age of 10.90 years (SD: 14.78 years) and an average body mass index (BMI) of 18.81 kg/m^2 (SD: 2.74). The gender distribution was balanced, with both boys and girls each constituting 50% of the study population. In terms of diagnosis, cerebral palsy was the predominant condition, affecting 45% of the participants. Ehlers Danlos syndrome was diagnosed in 20%, while other conditions such as arthrogryposis, Marfan syndrome, and syndrome 49 with xxxxy chromosomes (a variant of Klinefelter (19)) were less common. Regarding surgical interventions (Table 2), a significant portion (55%) of the participants had not undergone any. Achilles tendon lengthening was the primary surgical procedure, performed on 25% of the cohort. Additionally, 20% of the participants had received botulinum toxin injections. Orthotic use was prevalent in 55% of the participants, while 45% did not use them. When it came to insoles, 60% opted not to use them, with the remaining 40% incorporating them into their footwear. The study also shed light on various podiatric issues. Hyperkeratosis was observed in 30% of the participants, hyperhidrosis in 25%, and toe walking in 40%. Other conditions like brittle nails and ingrown toenails were noted in 10% and 40% of the participants, respectively. Misaligned toes were a concern for 30% of the cohort.

The data presents an exploration of the relationships between various foot conditions and the treatments or interventions applied. Ingrown Toenail & Orthotics: A notable association was observed between the use of orthotics and

TABLE 1. Demographic and Clinical Characteristics of Pediatric Participants with Neuromotor Disorders

Feature/Diagnosis	Frequency	% of Total	Cumulative %
Demographics			
Age (years)	10.90±4.78	-	-
Body mass index (kg/m^2)	18.81±2.74	-	-
Gender			
Men	10	50.0%	50.0%
Women	10	50.0%	100.0%
Diagnosis			
Arthrogryposis	1	5.0%	5.0%
Cerebral palsy	9	45.0%	50.0%
Ehlers Danlos syndrome	4	20.0%	70.0%
Marfan syndrome	1	5.0%	75.0%
Syndrome 49 with xxxxy chromosomes (Variant of Klinefelter)	1	5.0%	80.0%
Toe-walker	2	10.0%	90.0%
Undiagnosed genetic syndrome	2	10.0%	100.0%
Surgical Interventions			
Achilles tendon lengthening	5	25.0%	25.0%
Botulinum toxin injection	4	20.0%	45.0%
None	11	55.0%	100.0%
Orthotics			
No	9	45.0%	45.0%
Yes	11	55.0%	100.0%
Insoles			
No	12	60.0%	60.0%
Yes	8	40.0%	100.0%
Hyperkeratosis			
No	14	70.0%	70.0%
Yes	6	30.0%	100.0%
Hyperhidrosis			
No	15	75.0%	75.0%
Yes	5	25.0%	100.0%
Toe walking			
No	12	60.0%	60.0%
Yes	8	40.0%	100.0%
Brittle nails			
No	18	90.0%	90.0%
Yes	2	10.0%	100.0%
Ingrown toenail			
No	12	60.0%	60.0%
Yes	8	40.0%	100.0%
Misaligned toes			
No	14	70.0%	70.0%
Yes	6	30.0%	100.0%

TABLE 2. Associations Between Foot Conditions and Treatments or Interventions in Pediatric Patients with Neuromotor Disorders

Feature/Diagnosis	Category	No	Yes	Total
Ingrown Toenail vs. Orthotics				
Orthotics	No	8	1	9
	Yes	4	7	11
Total		12	8	20
χ^2	Value: 5.69	df: 1	**p: 0.017**	
χ^2 (with continuity correction)	Value: 3.71	df: 1	p: 0.054	
Hyperhidrosis vs. Insoles				
Insoles	No	7	5	12
	Yes	8	0	8
Total		15	5	20
χ^2	Value: 4.44	df: 1	**p: 0.035**	
χ^2 (with continuity correction)	Value: 2.50	df: 1	p: 0.114	
Orthotics vs. Surgical Interventions				
Surgical Interventions	Achilles tendon lengthening	0	5	5
	Botulinum toxin injection	1	3	4
	None	8	3	11
Total		9	11	20
χ^2	Value: 8.15	df: 2	**p: 0.017**	
χ^2 (with continuity correction)	Value: 8.15	df: 2	p: 0.017	

Legend: Achilles Tendon Lengthening: Surgical procedure stretching the Achilles tendon for greater ankle movement, Botulinum Toxin Injection: Treats muscle stiffness/spasms or movement disorders, Brittle Nails: Nails easily cracked, chipped, split, or peeled, Hyperhidrosis: Excessive sweating, often affecting the feet, Hyperkeratosis: Thickened skin, commonly on the foot, Ingrown Toenail: Nail growing into the toe, often leading to infection, Insoles: Inserts inside shoes for foot support and alignment, Misaligned Toes: Toes not aligning naturally due to various reasons, Orthotics: External devices modifying the neuromuscular and skeletal system, especially for foot support, Toe Walking: Gait abnormality with walking on the balls of the feet

the presence of an ingrown toenail. Specifically, individuals using orthotics were more likely to have an ingrown toenail. The statistical significance of this relationship was evident ($p = 0.017$), though it became borderline upon applying a continuity correction ($p = 0.054$). Hyperhidrosis & Insoles: There was a suggested relationship between the use of insoles and the absence of hyperhidrosis. All individuals using insoles did not exhibit hyperhidrosis. While the initial chi-squared test indicated a significant association ($p = 0.035$), the significance diminished with continuity correction ($p = 0.114$). Orthotics & Surgical Interventions: A clear association emerged between the type of surgical intervention and the use of orthotics. All individuals who underwent Achilles tendon lengthening used orthotics. The relationship was statistically significant ($p = 0.017$). Ingrown Toenail & Surgical Interventions: The data also hinted at a potential link between surgical interventions and the presence of an ingrown toenail. For instance, a majority of those who underwent Achilles tendon lengthening or Botulinum toxin injection had an ingrown toenail.

DISCUSSION

The data presented in this study offers a nuanced understanding of the relationships between various foot conditions and the treatments or interventions applied to pediatric patients with neuromotor disorders. The statistical findings further emphasize the indispensable role of the podiatrist in addressing and managing these conditions. A significant association was observed between the use of orthotics and the presence of ingrown toenails. While orthotics are designed to provide structural support, they might inadvertently contribute to certain conditions, possibly due to pressure distribution or the fit of the orthotic. The chi-square test indicated a significant association ($\chi^2 = 5.69$, $p = 0.017$), underscoring the importance of regular monitoring by a podiatrist. Contrary to our initial hypothesis, the data suggests that the use of insoles might be associated with an increase in hyperhidrosis or excessive sweating. This association was statistically significant ($\chi^2 = 4.44$, $p = 0.035$). The role of the podiatrist becomes even more crucial in recommending the right type of insole and providing guidance on managing associated conditions like hyperhidrosis. The data also indicates that individuals who underwent specific surgical interventions, especially Achilles tendon lengthening, were more likely to use orthotics. This association was statistically significant ($\chi^2 = 8.15$, $p = 0.017$), suggesting a post-operative requirement for additional foot support. The study also revealed a high prevalence of conditions such as brittle nails and hyperkeratosis. These findings underscore the importance of regular podiatric care, as untreated conditions can lead to further complications. However, this study has its limitations. The observational nature of the study means we can identify associations but cannot establish causality. Additionally, the relatively small sample size may limit the generalizability of the findings. Larger, controlled studies are needed to validate these observations. Furthermore, it is essential to consider the potential influence of external factors, such as footwear choices, daily activities, and overall health conditions, which might play a role in the observed associations. The multifaceted nature of foot health requires a comprehensive approach, integrating various medical specialties to ensure optimal patient care. The findings of this study pave the way for future research, emphasizing the need for interdisciplin-

ary collaboration and patient education to enhance the quality of life for individuals with neuromotor disorders.

Strengths:

Focused Cohort: The study specifically targets pediatric patients with neuromotor disorders, providing valuable insights into a specialized and often under-researched population.

Practical Relevance: The findings have direct implications for clinical practice, particularly in the field of podiatry, enhancing the understanding of treatment impacts.

Statistical Rigor: The use of chi-square tests for statistical analysis adds rigor to the findings, providing a reliable measure of the associations between different variables.

Limitations:

Observational Design: As an observational study, it can identify associations but cannot establish causality.

Small Sample Size: The relatively limited number of participants may affect the generalizability of the findings to a broader population.

Lack of Longitudinal Data: Without long-term follow-up, the study may not capture the full spectrum of the impact of treatments over time.

Potential for Unmeasured Confounding: There may be external factors not accounted for in the study that could influence the results.

CONCLUSIONS

In conclusion, while treatments and interventions like orthotics and insoles are valuable for patients with neuromotor disorders, the role of the podiatrist is paramount in ensuring optimal foot health. Their expertise is essential in monitoring, managing, and preventing potential associated conditions. Future studies should consider a larger sample size and a more diverse patient population to provide a more comprehensive understanding of these associations.

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SAŽETAK

Podološka analiza djece s motoričkim poremećajima (20 slučajeva) – naša iskustva

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Uvod: Pedijatrijski bolesnici s neuromotoričkim poremećajima često doživljavaju različita podijatrijska stanja. Učinkovitost i implikacije tretmana kao što su ortotika i ulošci u ovoj demografskoj skupini nisu u potpunosti shvaćene, naglašavajući značajnu prazninu u podijatrijskom istraživanju u kliničkoj praksi.

Prikaz slučaja: Ova opservacijska studija analizirala je 20 pedijatrijskih bolesnika s neuromotoričkim poremećajima. Fokus je bio na uobičajenim stanjima stopala kao što su urasli nokti i hiperhidroza i njihovoj povezanosti s tretmanima poput ortotike, uložaka i kirurških intervencija poput produljenja Ahilove tetive.

Klinička rasprava: Statistička analiza korištenjem hi-kvadrat testova otkrila je značajne povezanosti. Primjetno je da je korištenje ortotičkih pomagala povezano s većom učestalošću uraslih noktiju ($\chi^2 = 5,69$, $p = 0,017$). Nasuprot tome, uporaba uložaka korelirala je s učestalom hiperhidrozom ($\chi^2 = 4,44$, $p = 0,035$). Primijećena je I značajna tendencija za korištenjem ortoze kod pacijenata koji su bili podvrgnuti produljenju Ahilove tetive ($\chi^2 = 8,15$, $p = 0,017$). Studija je također istaknula prevalenciju lomljivih noktiju i hiperkeratoze među sudionicima.

Zaključak: Rezultati istudije naglašavaju ključnu ulogu podijatara u liječenju stanja stopala u pedijatrijskih bolesnika s neuromotornim poremećajima. Iako su intervencije poput ortoze općenito korisne, one također mogu pogoršati ili doprinijeti drugim stanjima, zahtijevajući redoviti i pažljivi podijatrijski nadzor. Studija zagovara buduća istraživanja s većim uzorkom i kontroliranim dizajnom studija kako bi se ta zapažanja dodatno potvrdila i proširila.

Ključne riječi: BOLESTI MOTORNIH NEURONA; PODIJATRIJA; PACIJENT; DIJETE; BOLEST STOPALA