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REVIEW

Structural and functional disorders in pediatric patients' foot

Defectos estructurales y funcionales del pie en pacientes pediátricos

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ABSTRACT

Introduction: foot deformities in pediatric patients comprise a broad group of disorders. They are the result of the interaction of exogenous and endogenous factors that can influence the infant's psychomotor development.
Objective: to characterize structural and functional defects of the foot in pediatric patients.
Method: a literature review was conducted. The search was conducted in the SciELO, PubMed, and Episteminokos databases using keywords and descriptors. A total of 44 studies were found, and 21 were selected to fulfill the objective of this study.
Development: the foot requires a perfect anatomical and physiological arrangement to ensure the fulfillment of its functions: walking and standing. Many of the disorders develop physiologically and are adequately resolved with conservative treatment. However, there are disorders that have a structural component and require intensive treatment (surgical in some cases) to ensure adequate psychomotor development. Disorders such as flatfoot and varus equinus are common in these age groups.
Conclusions: there are multiple structural or functional disorders of the foot in pediatric patients. They involve a complex condition that goes beyond the framework of a deformity, with a strong genetic or congestive component in its etiology or the conjunction of multiple exogenous factors. Each presents a distinctive symptomatic presentation depending on the characteristic anatomical defect.

Keywords: Foot Deformities; Pediatric Podiatrics; Flat Feet; Varus Foot; Varoequinus Foot.

RESUMEN

Introducción: las deformidades podálicas en pacientes pediátricos comprenden un amplio grupo de alteraciones. Son el resultado de la interacción de factores exógenos y endógenos que pueden influir en el desarrollo psicomotor el infante.
Objetivo: caracterizar los defectos estructurales y funcionales del pie en pacientes pediátricos.
Método: se desarrolló una revisión bibliográfica. La búsqueda fue realizada en las bases de datos SciELO, PubMed y Episteminokos a partir de la utilización de palabras clave y descriptores. Se encontraron un total de 44 investigaciones y seleccionadas 21 para dar cumplimiento al objetivo mediante el desarrollo del presente trabajo.
Desarrollo: el pie requiere de una disposición anatómica y fisiológica perfecta para garantizar el cumplimiento de sus funciones: la marcha y la bipedestación. Muchas de las alteraciones se instauran de una manera fisiológica y presentan una adecuada resolución con un tratamiento conservador. Sin embargo, existen alteraciones que tiene un componente estructural y requiere de un tratamiento intensivo (en algunos casos quirúrgicos) para garantizar un adecuado desarrollo psicomotor. Alteraciones como el pie plano, pie varoequino son frecuentes en estos grupos de edades.

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Conclusiones: son múltiples las alteraciones estructurales o funcionales del pie en pacientes pediátricos. Implican un complejo cuadro que sobrepasa el marco de la deformación desde un fuerte componente genético o congestivo en su etología o la conjunción de múltiples factores exógenos. Cada una ofrece un cuadro sintomático distintivo según el defecto anatómico característico.

Palabras clave: Deformidades Podalicas; Podopediatria; Pie Plano; Pie Varo; Pie Varoequino.

INTRODUCTION

Pediatric ages comprise a broad group of patients who, from a medical-care perspective, range from birth (newborns) to 18 years of age. However, the characteristics and implications for the psychomotor development of patients are specific to each period. During the newborn period (up to the first 28 days after birth) and until the end of the first year of life (known as infancy), the infant experiences accelerated growth compared to later stages, in addition to acquiring skills to ensure their adaptation to the external environment.

These functions will be perfected during the transitional, preschool, school, and adolescent stages, allowing for greater interaction with their peers and the rest of their environment. Learning ability, speech, the senses, and locomotion are some of these functions. In this sense, locomotion develops in conjunction with the musculoskeletal system (SOMA), including the bones (of the lower limbs, especially the foot) that enable functions such as standing. In this regard, structural or functional alterations can interfere with the proper development of these patients.

With an approximate incidence of 6 %, congenital disabilities are one of the causes of SOMA disorders that can be observed in pediatrics. Among the most common clinical forms are congenital hip dysplasia, varus or valgus deformities of the foot, and spina bifida, among others. However, despite current knowledge, their detection is most common between the ages of 4 and 5.[1]

Among foot disorders in pediatrics, valgus foot is one of the most common. It is a physiological variant that can be detected not only in early childhood but also in adolescence. On the other hand, flat feet are characterized by a loss of the normal medial longitudinal arch, associated with different anatomical conditions such as valgus deviations and joint subluxation. It is estimated to affect approximately 22 % of patients under the age of 15.[2]

Many factors can influence the development of these disorders. Neurological diseases such as paralytic muscle imbalances can trigger structural or functional disorders of the foot; similarly, diseases of the synovial joints, such as Charcot-Marie-Tooth disease, are relevant. Traumatic causes have been associated with poor management of injuries of this etiology (fractures, dislocations, sprains) as an important component.[3]

In addition to the above, authors such as Pérez Brian et al.[4], Robayo Zurita et al.[5], and Galindo Galeano et al.[6] discuss the relationship between endocrine and metabolic disorders and lifestyle with SOMA defects. According to these authors, they highlight the importance of these stays for the psychomotor development of infants and how obesity can influence the development of poor posture and increased habits that can lead to greater musculoskeletal disorders. Similarly, there is a higher incidence of fractures in obese pediatric patients compared to the rest.

Due to their high prevalence and frequency of occurrence, knowledge and understanding of structural abnormalities are key to the development of appropriate and timely diagnostic and therapeutic management. Early detection and treatment of these conditions can reduce the number of future complications. The authors of this study aim to characterize structural and functional foot defects in pediatric patients.

METHOD

A literature review was conducted on structural and functional deformities of the foot in pediatric patients. The search was carried out in the Scielo, PubMed, and Episteminokos databases using keywords and descriptors (defined by Descriptors in Health Sciences and their English equivalents). In addition, the Google Scholar search engine was used. Similarly, Boolean operators were used to link each of the terms. Each of the studies found was analyzed (title, abstract, and content) to assess its relevance to the research. A total of 44 studies were found, and 21 were selected to fulfill the objective of this study.

DEVELOPMENT

According to anatomical and functional descriptions based on the principles of biomechanics for the functioning of the SOMA, the foot (as a structure) must meet certain characteristics to perform its basic functions: standing, balance, and walking. The angle formed by the intersection of lines drawn from the lowest point of the calcaneus, the head of the talus, and the base of the first metatarsal is called the Moreau-Costa-Bartani angle, which should normally vary between 120 and 130 degrees. The Kite angle, with a variation

of 15 to 20 degrees, is formed by the junction of the longitudinal axis of the calcaneus and the talus in the dorsoplantar projection. In addition to these characteristics, there are other longitudinal arches (emerging from the first toes to the calcaneus) that decrease progressively.[3]

Within podiatry, pediatric podiatry focuses on the study of injuries that appear on the infant's foot. Many of the alterations are physiological and resolve adequately with conservative treatment. However, some alterations have a structural component and require intensive treatment (in some cases, surgical) to ensure proper psychomotor development.[7]

Characteristics of the normal foot in children. Physical examination

Before beginning the clinical examination of the patient, it is necessary to emphasize the importance of questioning the parents or the family member in charge of the infant. During the questioning, the reason for the consultation should be specified (it may be due to a visible deformity or alterations in gait or standing). Similarly, explore the personal or family medical history and delve deeper into those considered of interest.[8]

From a general point of view, the feet of pediatric patients do not usually have multiple abnormalities compared to adults. They do not present visible abnormalities, are lax without deterioration due to walking or calluses, or skin lesions. The clinical evaluation will consist of two stages:[8]

First stage: the patient's gait should be examined (with or without shoes) to determine whether the cause of the defect lies in the foot or is due to other conditions such as muscular dystrophy, paralysis, or other disorders. The patient's steps should be evaluated over a distance (as determined by the healthcare professional); the examiner should look for even foot support on the surface, whether the heel strikes the ground first compared to the rest of the structures, the presence of free rolling, and whether the support is stable during the monopodal phase.

The data provided by this stage, in the opinion of the authors of this paper, is key to the accuracy and initial assessment of structural and functional injuries. In turn, they can help to make a differential diagnosis and refer the patient to other specialists if necessary. Similarly, at this stage, additional tests that will be vital for a comprehensive assessment can be specified.

Gait itself corresponds to a coordinated process of successive steps involving the heel striking the ground first, followed by the rest of the body, involving bipedal and monopedal processes that ensure the biomechanical process of walking. According to pediatric podiatry, the gait process in patients evolves in stages: at birth, support and automatic gait are explored through reflexes, together with kicking, which are necessary. This stage is followed by rolling over and then sitting.[9,10]

At 7 months, the infant can begin crawling, which is replaced by bipedal standing at 10 or 11 months of age. At around 12 months, the walking process should begin, maturing throughout 2 to 3 years.[9,10] Without a doubt, the walking process is a complex event that goes through multiple stages. Each stage must be thoroughly explored and evaluated to identify possible structural and functional abnormalities that could compromise or disrupt the infant's development.

The second stage involves the direct examination of the foot by the examiner. According to the logical order of the physical examination and its four basic maneuvers, the examination should begin with a direct inspection of the region to determine the presence or absence of skin lesions, obvious deformities, and/or inflammatory changes. This examination is performed in an orderly manner from front to back, beginning with the forefoot, followed by the midfoot, and ending with the hindfoot. The evaluation of the main joints should also be taken into consideration.[8]

About the clinical data that can be collected from the physical examination of flat feet, the footprint is a notable example. This is classified into degrees according to the deformity. Grade 1 shows a slight deformity of the arch of the foot. Grade 2 shows a disappearance of the longitudinal arch of the foot, and grade 3 shows a deformity of the inner edge of the foot, which is observed to be connected. Other special tests can be performed, such as the Fonseca test or heel rise test, Jack's test, or flexibility tests.[11]

Once the alterations have been identified, they are classified as structural or rigid deformities (often requiring surgical treatment) or flexible or functional deformities requiring physiotherapy sessions. Similarly, instruments such as a podoscope may help evaluate the footprint.[8]

Understanding these anatomical and functional characteristics is key to detecting possible alterations by healthcare personnel. In addition, a preventive and educational approach should be taken, involving the family, especially parents, in the systematic assessment of their children's psychomotor development (especially gait and feet) to detect any possible alterations promptly.

Structural and functional deformities.

Flat feet (mostly flexible) are considered a physiological abnormality in pediatric patients. It is generally a defect that corrects itself with the patient's growth and development; only about 10 % require surgical treatment and are more common in adults. From a structural point of view, it is caused by a lack of muscle

strength and ligament insufficiency. It is usually diagnosed by direct examination of the foot, the patient's gait, and the use of a footprint and a podoscope.[8,12]

In turn, this can be classified as a flexible flat foot or a rigid flat foot. The former is characterized by the presence of the arch when the foot is suspended in the air; that is, there is no pressure on the ground. Rigid flat feet, on the other hand, are characterized by the absence of the arch of the foot regardless of the situation.[13] It has been associated with several risk factors, including hyperlaxity, obesity, wearing shoes before the age of 6, and the level of physical activity, among others.[14]

It is associated with disorders such as congenital vertical talus, tarsal coalition, and cerebral palsy, among others. It is estimated that approximately 75 % of patients in early childhood have this injury. In addition to being associated with other disorders such as physiological exaggeration of the femorotbial angle (genu varum or genu valgum), these figures gradually decrease with age, with a prevalence of 2,6 to 12,5 % in adolescence.[12]

About the research carried out by Nápoles Macías et al.[15], the anthropometric characteristics of patients with flat feet in a province of Cuba were analyzed. The study highlights the relationship and high frequency of flat feet with overweight or obesity (present in more than 50 % of the cases analyzed), which the authors recognize as a factor of vital importance that must be studied both in the diagnosis and in the treatment of the deformity.

On the other hand, another study conducted by Martínez de Sus et al.[16] with Spanish schoolchildren on the relationship between body weight and foot posture in children shows a predominance of flat feet over other disorders. Although the authors do not show a direct relationship between weight-related pathologies and foot deformities, it is worth noting the high number of overweight and obese patients in the study.

These results are alarming and can serve as a starting point for the team responsible for pediatric care to promote health and prevention, aiming to avoid future complications caused by overweight, including foot deformities in children.

The results shown by Giron Gomez et al.[17] show a significant relationship between joint hypermobility and the development of flat feet. Their research shows that more than 50 % of patients diagnosed with childhood foot deformities were associated with joint hypermobility, with a greater impact on children under 14 years of age.

Flat feet are undoubtedly one of the most common deformities in pediatric patients. Their implications and possible etiologies require healthcare personnel to thoroughly evaluate each characteristic to identify potential complications and develop therapeutic and preventive measures.

For its part, a cavus foot corresponds to a structural lesion of the foot that may be secondary to peripheral polyneuropathies or cerebral palsy. The deformities begin on the medial side of the foot and progress over time. This deformity may be present from birth, where it coexists with other lesions such as adducto and equinus deformities. From an etiological point of view, it may be due to congenital or acquired causes such as muscle paralysis or significant neurological disorders. It is usually diagnosed by ruling out other foot disorders, with priority given to a possible neurological disorder such as Charcot-Marie-Tooth hereditary sensory-motor neuropathy, which is the cause of 50 % of diagnosed cases.[8,12]

Vaorquieno's foot is a structural disorder with a congenital cause. It was first described by Hippocrates in 400 BC. Its development may be influenced by external or maternal factors, such as smoking and others, such as the first pregnancy, especially in young mothers, among others.[12,18]

From an anatomical point of view, the deformity corresponds to an inversion and adduction displacement located below the astragalus, which remains fixed in its anatomical position around the Farabeuf's Y-shaped ligament or talocalcaneal joint. These alterations, together with plantar flexion, complete the picture, which clinically translates into an inability to move the joints and the foot itself independently. In addition, there are calluses and other alterations in the medial portion of the foot. Thanks to the rapid development of diagnostic and ultrasound techniques, this deformity and others can be diagnosed quickly and prenatally. However, the presence of a foot deformity may be a precursor to other SOMA disorders.[12]

In this regard, the authors consider the importance of medical ethics in these cases. Although some of these cases may be associated with simple compression or poor positioning of the foot in the maternal womb, with a good outcome for the patient, others involve a greater risk, especially when considering the aforementioned risk factors for the development of these pathologies.

The results shown by Anccasi Yaranga et al.[19] show a predominance of males as the leading carriers of this deformity compared to females. In turn, there is a greater tendency for bilateral presentation.

About complex conditions and those related to complex syndromes, there is a deformity called convex skin or vertical talus. This is a condition that has been associated with preterm birth. From a pathophysiological point of view, it represents the exact opposite of clubfoot. The calcaneal-pedal block is everted and abducted, therefore in valgus. The similarity with clubfoot is the equinus of the hindfoot, as the talus assumes a vertical position. There is a dorsal dislocation of the Chopart joint with retraction of the extensor tendons, tibialis anterior, and peroneal tendons, which determines the talus of the midfoot.[12,20]

Other deformities that may occur include juvenile hallux valgus, a congenital malformation of the first metatarsal, which may involve deformities or make it impossible to wear shoes. On other occasions, metatarsus adductus appears secondary to compression by the uterus during development; this requires conservative treatment as it may resolve spontaneously.

Other research has focused on the study of podiatric deformities in pediatrics in association with other SOMA disorders. Such is the case of the survey conducted by Méndez Viveros et al.[21], which shows a relationship between hyperlaxity and flat feet in 38,6 % of cases and 8,8 % of cases of cavus foot deformity.

CONCLUSIONS

There are many structural or functional foot disorders in pediatric patients. They involve a complex picture that goes beyond the framework of deformation, with a strong genetic or congestive component in their etiology or the combination of multiple exogenous factors. Each one offers a distinctive set of symptoms depending on the characteristic anatomical defect.

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