MODIFICĂRI POSTURALE LA COPIII ȘI ADOLESCENȚII CU ANOMALII ALE PICIORULUI – O REVIZUIRE SISTEMATICĂ

POSTURAL CHANGES IN CHILDREN AND ADOLESCENTS WITH FOOT ABNORMALITIES – A SYSTEMATIC REVIEW

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Abstract

Postural faults in children and adolescents represent one of the most popular yet underestimated health problems because of the subsequent complications they may produce. One of the causes that can contribute to the young organism's posture disorders are the alterations in the foot's structure and functionality, which are more and more frequently discovered. This study aimed to investigate the postural changes induced by foot deformities and/or dysfunctions in children and adolescents. The methodology involved a systematic search using Clarivate Analytics, PubMed, ResearchGate, and Google Scholar databases in order to obtain information regarding the postural changes associated with foot abnormalities; 188 articles were found after we applied the inclusion criteria, but finally, only 17 were relevant to our research. The analysis of these showed that: there is evidence for poor postural stability in the pronated and supinated foot, foot deformities are a risk factor for injuries of the lower extremity due induced postural changes, foot position can influence the pelvic alignment in children (especially, an increased anteversion of the pelvis on those with hyper pronated foot), can produce trunk asymmetries, and also can change the gait kinematics and create an excessive load on various joints of the spine and lower limb. In conclusion, is confirmed the idea that even a minor alteration in foot structure and/or functionality is followed by poor postural habits based on feedback and other advanced control mechanisms. These changes could lead to more complicated health issues.

Keywords: *posture, foot deformity, foot posture, children, adolescents*

Rezumat

Deficiențele posturale la copii și adolescenți reprezintă una dintre cele mai populare, dar totuși subestimate probleme de sănătate din cauza potențialelor complicații ulterioare. Una dintre cauzele care pot contribui la tulburările posturale ale organismului tânăr sunt modificările structurii și funcționalității piciorului, care sunt descoperite din ce în ce mai frecvent. Acest studiu a avut ca scop investigarea modificărilor postural induse de deformările și/sau disfuncțiile piciorului la copii și adolescenți. Metodologia a implicat o căutare sistematică utilizând bazele de date Clarivate Analytics, PubMed, ResearchGate și

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Google Scholar pentru a obține informații cu privire la modificările posturale asociate anomaliilor piciorului. Au fost găsite 188 de articole care îndeplineau criteriile de includere, dar, în final, doar 17 au fost relevante pentru cercetarea noastră. Analiza acestora a arătat că: există dovezi pentru o stabilitate posturală slabă la piciorul pronat și supinat, deformările piciorului sunt un factor de risc pentru leziunile extremității inferioare datorate modificărilor posturale induse, poziția piciorului poate influența alinierea pelviană la copii (în special, o anteversie crescută a pelvisului la cei cu picior hiperpronat), poate produce asimetrii ale trunchiului și, de asemenea, poate schimba cinematica mersului și poate crea o sarcină excesivă asupra diferitelor articulații ale coloanei vertebrale și ale membrului inferior. În concluzie, se confirmă idea că și o modificare minoră a structurii și/sau a funcționalității piciorului este urmată de modificări posturale defectuoase bazate pe feedback și pe alte mecanisme avansate de control. Aceste schimbări ar putea determina probleme de sănătate mai complicate.

Cuvinte cheie*:* *postură, deformarea piciorului, postura piciorului, copii, adolescenți*

Introduction

Posture is described as a set of interactions between the musculoskeletal system and the central nervous system and its main role is to keep the body in a state of balance by protecting its supporting structures against injuries or progressive deformities [1].

Movement and postural patterns are essential components of a child's physical and emotional development [2]. Body posture failures in children and adolescents constitute one of the most popular yet underestimated health problems. A sedentary lifestyle among children and adolescents is an important factor that intensifies incorrect body postures in daily activities [3, 4]. Nowadays, we are dealing with an increased number of children and adolescents who have musculoskeletal pain without trauma [4, 5].

The human foot plays a fundamental role by linking the body with the ground. Therefore, it is a significant contributing factor in the overall development of the musculoskeletal system in children [6]. Foot misalignment is one of the most common orthopedic issues in pediatric health and it leads to many injuries in the foot, knee, and lower back. If normal foot posture does not develop during the elementary school period, foot misalignment continues to evolve during adolescence and into adulthood. Therefore, the development of normal foot posture during childhood is essential [7].

The entire kinematic chain can be disrupted by any minor dysfunctions within the foot and consequently affects its motility. Dysfunctions of the locomotor system, though, may cause lower limb failure, translating into degenerative changes in the peripheral and spinal joints [8]. From a biomechanical point of view, foot posture can influence postural stability, bodyweight distribution, change the normal kinematics of gait, it can alter the position of the pelvis, and increase the risk of injuries.

Objective. The aim of this study is to investigate the effect of foot deformity, dysfunction, or both on postural alignment.

Materials and Methods

A computerized database search was performed to identify relevant articles for this review. The following databases were searched Clarivate Analytics, Pubmed, ResearchGate, and Google

Scholar. Selection criteria were based on the publication date (between 1990-2020), their accessibility (free full text), and using the following keywords: *posture, foot deformity, foot posture, children, and adolescents.* The studies involving adult subjects and the articles that do not have their main topic foot deformity in associations with posture were excluded.

A total of 188 studies were found in selected databases. After analyzing their content, a total of 17 articles were eligible to be included in this review.

Results

The results obtained were divided according to the effect described by certain pathology of the foot on the posture or posture-related conditions in children and/or adolescents.

- Postural stability

Four studies investigated how foot abnormalities correlate with postural stability. Cote et.al (2005) included children and adolescents with foot structural classification (supinated, pronated, and neutral) and they measured center of balance, stability index, and postural sway during static single-limb stance under eyes-open and eyes-closed conditions. They found that postural stability is affected by foot type under both static and dynamic conditions [9].

Szczepanowska-Wolowiec et al. examined (in 2019) 200 children by measuring the center of pressure (COP), using a dynamometric platform and they found a correlation between morphological variables of the foot and postural stability [8].

The effects of flexible pes planus on postural stability examined by El-Shamy and Ghait determined that there was a decrease in postural stability in adolescent females with flexible pes planus compared with normal subjects [10].

In another study, the authors measured ground force reaction (GFR) in children with flat feet. They found that flexible flat feet were associated with a reduction in the second peak of the vertical GRF, a reduction in peak ankle inversion, external rotation moments, and an increase in peak ankle eversion moment impulse. These findings add support to the belief that flexible flat feet lead to instability and abnormal foot and ankle loading [11].

- Pelvic position

Two studies identified a correlation between foot posture and pelvic alignment. One study found significant relationships between the position of heel valgus, hip rotation, and pelvic tilt. A higher anterior tilt of the pelvis was found in children during the whole gait cycle [6].

The second study involved 651 children whose footprints and internal, external rotation of both hips were measured. All of 151 children with flat feet had presented an increased internal rotation of hip; a highly significant correlation was found between flat feet and increased hip internal rotation in children [12].

- Trunk parameters

One study investigated the relationship between selected parameters of feet and trunk in children aged 4 to 6 years. Parameters of feet were significantly correlated with the angle of the body bent to the left in the frontal plane (63.01%), the height of lumbar lordosis (52.15%), the inclination of upper thoracic region (41.29%), and length of lumbar lordosis (39.11%). Foot

parameters were reported to correlate significantly with the length of thoracic kyphosis (13.04%), the inclination of the lumbosacral region (10.86%), and asymmetry in the distance between lower angles of the scapula from spinous process, with the lower angle of the left scapula being more distant. The authors revealed a significant relationship between foot parameters and trunk parameters especially in the sagittal plane than in the frontal (very low in the transverse plane); also, the authors established that left foot parameters are better correlated with trunk parameters than the ones in the right foot [13].

A positive correlation was found in one study between abnormal foot pronation and the development of scoliotic curves. The study suggests that asymmetrical pronation patterns may be a critical factor in the development of scoliotic curves.
The authors described that if a foot pronates more than the other the pelvis will rotate counterclockwise and tilt downwards towards the foot that pronates more [14].

- Kinematic gait parameters

Children with heel misalignment were examined and pressure distribution on the foot during gait was analyzed on a force platform. The results show the heel's valgus positioning influences foot loading in children during gait and the presence of pathological changes[15].

Another study investigated the relationship between foot arch and dynamic plantar pressure in preschool children. They measured 27 children for static foot posture, including navicular height and plantar pressure force, and contact areas using a 3D foot scan. They concluded that the foot arch is a factor which will influence the pressure distribution under the foot. Therefore, children with flatfeet may shift their body weight to a more medial foot position when walking and could be at a higher risk of soft tissue injury in this area [16].

GRF and support moment in normal and flat-feet children were investigated by Pauk and Griškevičius. They investigated GRF and were quantified by three vectors, in the vertical, anterior-posterior, and medial-lateral planes. They suggest that children with flat-feet tend to walk with a reduced compliance in the loading response phase due to the impaired function of the hindfoot. The amplitude of the force in posterior direction was significantly lower in flat feet children compared with normal subjects. They also study the support moment of all the joints of the lower limbs and concluded that the support moment was lower in the flat-feet group (the hip joint 21.3% for control group vs. 15.6% for flat feet subjects; the knee joint 20.3% for control group vs. 17.7% in flat feet subjects) [17].

- Whole-body flexibility

The relationship between foot posture and body flexibility in healthy asymptomatic children aged 7 to 15 years was assessed by Hawke and colleagues. They found that children with increased pronation of the foot type exhibited greater lower limb and whole-body flexibility but not greater ankle joint flexibility [18].

- Lower extremity injuries

Five studies identified foot posture as a risk factor for the development of injuries in the lower extremity. Two studies evaluated athletes with either pronated or supinated foot and reported a higher incidence in knee pain and risk of overuse injuries [19, 20].

A 125 high school cross-country runners were measured for tibiofibular varum, resting calcaneal position during gait stance, and gastrocnemius length. They supported the hypothesis that a pronated foot type is related to medial tibial stress syndrome (MTSS) with an accuracy of 76% [21].

Two studies investigated symptomatic flat feet and proximal joint problems. Both pieces of research reported that flatter foot posture is more likely to have pain or discomfort at the hip, knee or back. These results suggest that foot motion in the transverse plane is closely associated with the presence of symptoms in flat feet and is accompanied by changes in the ankle, knee, and hip kinematics [22, 23].

Discussions

This review reports data on the relationship between foot posture and association with the whole body or conditions related to a bad posture among children and adolescents.

Findings showed that foot type could be a risk factor for developing pathological changes in the kinematic chain. The results confirm the findings of previous reviews as we found that. B. Neal and colleagues investigated foot posture and function as a risk factor for lower limb overuse injuries. Studies were classified based on foot assessment method using foot posture index (FPI), navicular drop, and the longitudinal arch angle. They found a strong correlation between pronated foot posture and medial tibial stress syndrome and minimal evidence that a pronated foot posture was a risk factor for patellofemoral pain development. They investigated foot posture as a risk factor for the development of foot/ankle injury and bone stress reaction but they did not find any association between them [24].

Another study found that body posture influences load distribution in the lower limbs. They examined body posture among 78 children using the photogrammetric method and for plantar pressure they used a baropodometric pressure platform. In this study, the results showed a significant relationship between body posture failures in children such as the increased angle of thoracic kyphosis and the angle of lumbar lordosis and the load transferred by the forefoot/hindfoot. A greater angle of inclination in the thoracolumbar segment correlated with greater load transferred by the forefoot as a consequence of the forward shift of the center of gravity. Postural defects in children can influence the load distribution of both feet and the position of the center of gravity which suggests that not only foot posture can create asymmetries and compensation mechanisms inthe kinematic chain but also any alteration in body posture can influence the whole alignment [25].

Zaharieva investigated foot posture (flat feet, prone feet) in relation to posture and their association in children. A strong correlation was found between pronation and postural deviations, pronation being the leading factor for the variation in the children's posture [26]. Outcome measures are important when evaluating the effectiveness of treatment and progress towards a final goal in pediatric populations. There are a lot of conditions seen in pediatric orthopedic clinics and it is not clear how and when children develop normal foot posture and function and also when a deformity is defined as pathological.

The reliability of clinical foot measures commonly used in pediatric foot assessments has been previously investigated in various ways and for different purposes.

In one study the examiners found largely good intra-rater and inter-rater reliability for the FPI-6, Lunge test, the Beighton scale, and the lower limb assessment score (LLAS). Navicular

height (NH), the Foot Posture Index (FPI), resting calcaneal stance position (RCSP), neutral calcaneal stance position (NCSP), navicular drop (ND) were examined in young children(4 to 6 years) and adolescents (8 to 15 years) in an intra-rater and inter-rater reliability study [27].

It is known that foot posture and ankle range may influence the entire postural alignment and it is pertinent to identify the most useful measures for the clinical evaluation of these parameters. These findings indicate that the presented measures are useful in assessing the deformities of the foot that may lead to postural abnormalities [28].

The Foot Posture Index (FPI-6)was assigned to a predetermined category: highly pronated (FPI-6 score 10 to 12), pronated (FPI-6score 6 to 9), neutral (FPI-6 score 0 to 5), supinated (FPI-6 score -1 to -4) and highly supinated (FPI-6 score -5 to -12). The inter-rater reliability when the actual score was compared and when the score was categorized showed almost perfect agreement. The findings of this study show the FPI-6 has almost perfect inter-rater reliability and suggests that the FPI-6 may be of value in clinical practice [28].

Conclusion

This review identified evidence on the effects of foot posture on the entire postural alignment. We found a strong correlation between foot types and lower limb injuries and postural stability in children and adolescents. However, in the studies evaluated we found that foot posture can alter kinematic gait parameters and create an excessive load on the various joints. Any abnormality in foot posture or its functionality will create methods of compensation in the kinetic chain by postural adjustments based on feedback and advanced control mechanisms. Evaluation of static foot posture and dynamic foot functionality should be included in a multifactorial assessment in children and adolescents with foot deformities.

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