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ESSAY REGARDING THE NEED FOR A STANDARD FRAMEWORK OF ASSESSMENT AND MEASUREMENT OF FLAT FEET IN CHILDREN

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Abstract: *This study aimed to analyze various conceptions of approaching flat feet in children, trying to highlight the similarities and the differences between the theoretical and clinical approaches of the rigid and flexible flat feet. Although they have much in common, it was not possible to clearly determine a national or international standard framework of assessment and measurement of flat feet in children. The researchers studied for this paper offered guidelines for measurement, various theories, assessment approaches and relevant scientific arguments, however it is still not possible to delineate a common line for standardization in regard to measurement and assessment*

Key words: *flat feet, children, assessment, measurement, standardization.*

1. Introduction

The factors causing postural deformities in humans are, over the last decades, increasingly analysed and studied from an interdisciplinary perspective, which has led to various propositions and approaches, both in determining the postural deformity and the rehabilitation processes [35], [38], [41].

Professional literature constantly discusses one of the most known postural deformity: flat feet. The attempts to

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define and/or delineate flat feet, present in various sources, highlight different points of view, from osteoarticular deficiencies during growth to genetic factors and normal physiological states during the growth and development stage, all these approaches bringing up the tight dependence on either congenital causes, or rickets, or exaggerated supine position of the feet, precocious walking, or acquired conditions (disorders in the contralateral foot, difficult professional activity that is asymmetrical and demanding for the foot, a sedentary lifestyle, overweightness, etc.) [46], [48].

Studying the early childhood, Uden et al. (2017) [44] emphasized the relationship between age and body growth regarding the causes for flat feet, arguing that all new-borns have flexible flat feet due to their innate ligamentous laxity and plantar adipose tissue. As the child grows, her medial longitudinal arch of the foot develops, and the adipose tissue is absorbed.

Existent studies give a prevalence of flat feet between 0.6 - 77.9%; however, these numbers are not relevant, because, according to Evans (2011) [10], they are disparate values that are more or less influenced by the subjects' age, by the methods used to evaluate and measure, by the population samples and by other factors.

Despite that this disorder is frequent, flat feet in children remain a subject with no clear conclusions [30], [37], while professional literature shows that it is still difficult to establish how flat the feet should be in the first 10 years of the child's life.

In the next section there will be a literature review in regards to the classification of flat feet, their prevalence, aetiology, structural modifications, clinical and functional diagnosis, assessment of the medial longitudinal arch (as a guideline often used by the experts), and the need to differentiate between flexible and rigid flat feet, without claiming to exhaust all aspects in the analysis of flat feet in children, but trying to take another step towards its understanding.

2. Content

A. Classification

International classifications of flat feet, found in various studies state the following criteria: the height of the longitudinal arch, the valgus of calcaneus, the height of the navicular bone, etc., but the classification most often encountered is the one that divides flat feet into *flexible* and *rigid* (figure 1).

The first type manifests as a flattening of the medial longitudinal arch when body weight acts on it (an aspect that diminishes after this force stops being applied, the plantar arch returning to its initial shape).

The second type is the one that stays permanently flattened, having a certain rigidity, seen by experts as a pathological variant caused by an abnormal development of bones and joints. According to Atik and Ozyurek (2014), [1], the specific rigidity of this type of flat feet is present since birth, the symptoms appearing toward the end of the first 10 year of the child's life, based on various causes (coalition of tarsal bones, congenital vertical talus, flat feet caused by the spasm of the peroneus muscles, which needs urgent diagnosis and therapeutic intervention).

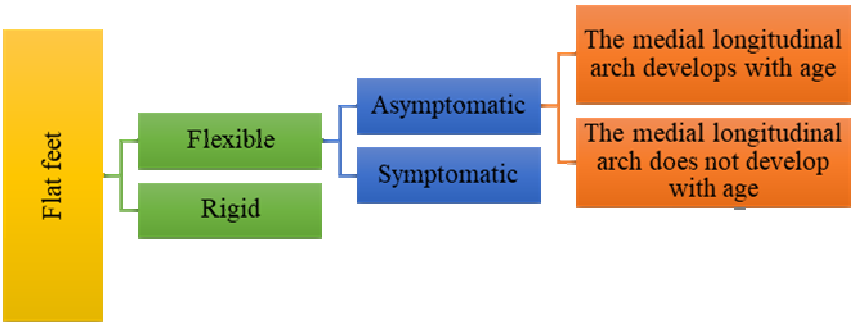

Fig. 1**.** *Classification of flat feet*

Because of their specificity and functional manifestations during childhood, experts have observed two forms of manifestation for flexible flat feet, the *asymptomatic* (figure 1, believed to be the physiological variant, normal for a child's feet, existing the possibility to correct them with age. It must be said here that their persistence after the age of 6-8 would need extra investigation, even if there are no symptoms) and the symptomatic one (which manifests through pain or the perturbation of the foot's static and dynamic functions).

B. Prevalence

In regards to the prevalence of flat feet, one must analyse the factors that would form the basis for a scientific determination of the interested aspects, such as: age, gender, family history, constitution type, ligamentous laxity, the children's age at the time when they first started wearing shoes, the quality of their shoes, etc.

Previous studies discuss the fact that 97% of 2-year-old children have flat feet, and, over time, toward the age of 10, the percentage is reduced considerably, only 4% remaining with this deformity [25]. Continuing on this subject, in a study conducted in Nigeria, Didia et al. (1987), [8] state that subjects between the ages of 5 and 14 were found to have lower values of flat feet prevalence. The authors examined the feet of 990 subjects and discovered an average value of approximately 0.60% (an average determined by female values of 0.75% and male values of 0.44%). Analysing the gender criterion, El et al. (2006), [9] observed similar values and confirmed the fact that females are more predisposed to flat feet than males.

Other recent studies [33] conducted on children between the ages of 3 and 6, determined a flat feet prevalence of 44%, of which 54% in 3-year-olds and 24% in 6-year-olds. At the age of the subjects studied by these authors the results showed that the boys were more predisposed than the girls, with a score of 52%, compared to 36%.

For the age category of 5-13, the prevalence of flat feet in a study by Chen et al. (2009), [5] was of 28%. The same as in Pfeiffer's study [33], the prevalence of flat feet was higher in boys than in girls (35% vs. 20%).

Studies conducted by Mortazavi et al. (2007) [27] showed that all children are born with flat feet and more than 30% of

the new-borns have a valgus calcaneus at both feet.

The diversity of opinions expressed in other studies, such as the ones by Evans, (2021) [11], according to which 45% of preschool children and 15% of an average age of 10 have flat feet), by Rao (1992), [36] who studied the feet of 2300 children and got a prevalence of 14.9% in preschool children and only 2.5% in older children) confirm that flat feet ratio in children reduces naturally with age, but the percentages are not fixed to certain values that should be taken as guidelines.

C. Aetiology

Starting from studies conducted a long time ago, between 1910 and 1942, studies that were limited by a lack of information and diagnosis techniques, stating that flat feet was caused by the inability of the muscles and ligaments to manipulate the stress imposed by body weight [18], the analysis of flat feet in children acquired new approaches. Thus, Harris & Beath (1948), [19] thought that the foot and ankle muscles re-establish the balance lost following bone and ligament injuries. Later, in 1968, Gray & Basmajian, [16] analysing the bones and ligaments through electromyographic studies, emphasized that maintaining the medial longitudinal arch is conditioned by its optimal function and not by the ankle and foot muscles. These authors attributed other functions to the muscles: maintaining the balance, adapting the foot to irregular surfaces and moving the body forward.

In Romania, Baciu's research (1972), [2] mentions that no matter how weak are the links between the arches and support points of the plantar arch, they are helped by the relatively cuneiform shape of the bones. The Romanian author thought that the other structures contribute as well to the optimal function of the foot, accentuating the importance of the plantar aponeurosis, which he considered "the tyrant that does not allow the plantar arch pylons to spread apart."

In regards to the relation between weight, feet load and the arch plane, Farzin et al. (2013), [14] accentuates the idea that both the lack of neuromuscular control and ligamentous laxity determine the flattening of the foot when it is loaded. In the same line, regarding the same criterion (body weight load), Popescu and Cotescu (2013), [34] seem to confirm Farzin's idea, but they complete it with aspects that show that flat feet are created as a result of the weakening of muscles, ligaments and bones to the demands of excessive body weight or professional overload. In 2018, Lupu [21] adds that the repetitive overload of the foot causes the injury of the tendinous and ligamentous structures that are responsible for the stabilization of the foot, which would lead to the deformation of the bones, the person acquiring bad postures, finally leading to flat feet.

In regards to the relation between flat feet and other disorders, figure 2 presents, in an original and suggestive form, a synthesis of the opinions expressed in the professional literature about flat feet as an isolated pathology or as part of other disorders.

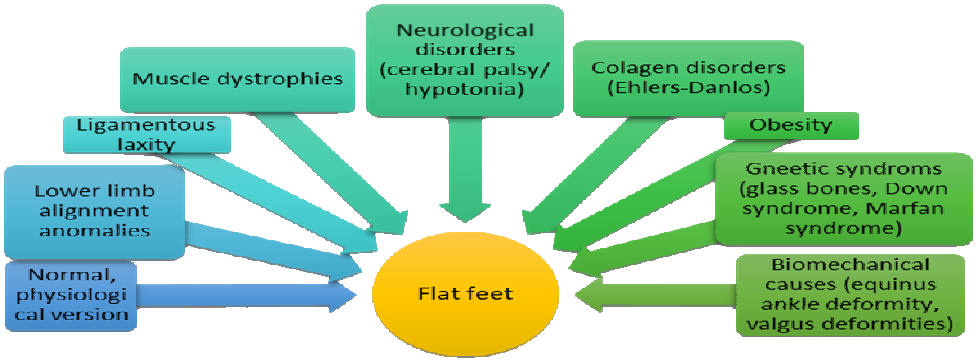

Fig. 2. *Etiology of flat feet*

D. Structural modifications of flat feet

The severity of the structural modifications generated by flat feet imposes, according to experts, an early diagnosis of the symptoms, using various methods. By analyzing the structural modifications, some researchers focus on the rearfoot valgus as one of the frequent characteristics of flat feet.

Using medical imagery, some researchers [32] observe, in subjects with flat feet, a flattening of the posterior part of the navicular bone, which would cause an extension of the joint area with the talus.

Analyzing the structural modifications of the feet, Ezema et al. (2014), [13] suggest that flat feet manifest also through the plantar flexion of the talus, of the calcaneus in relation to the tibia (equinovarus), dorsal flexion and abduction of the navicular bone and the abduction and supination of the forefoot. Supporting the conclusions of Ezema et al. (2014), [13] Dare & Dodwell (2014), [7] claim that the previously mentioned modifications cause the flattening of the medial longitudinal arch.

Other studies in the field of biomechanics show that the structural modifications of flat feet are manifested more than through a simple diminishing of the medial longitudinal arch or of the eversion angle of the calcaneus, but they say that in some cases the medial side of the foot becomes convex and determines the total contact of the plantar surface with the ground. These positions cause exaggerated tensions in the deltoid ligament and the posterior tibial muscle, whose functions are inhibited. Thus, together with the rearfoot valgus, the function of the medial and forefoot is perturbed, which would make the upper segments elaborate compensatory responses to solve the problems imposed by this posture and to maintain balance.

Multiple studies show that during childhood flexible flat feet is most of the times asymptomatic, but the literature highlights also that the normalization can appear up to the age of 8-10, sometimes later, persisting into adolescence [29].

Nevertheless, after the symptoms emerge, many experts say that flat feet become symptomatic.

Another interesting point of view is the one presented by Bresnahan and Juanto (2020) [4], who do not agree with the myth of "auto-correction", drawing attention toward the experts' decision to ignore the therapeutic approach of flat feet, observing that the modifications of bone structures do not realign by themselves, and if the external forces continue to act on the feet, they will compensate up to a breaking point.

E. Clinical-functional diagnosis

Experts have tried to clarify the diagnosis methods, studying the feet posture through visual inspection, examination of the medial longitudinal arch, eversion of the calcaneus, height of the navicular bone, etc. The results have shown that from a clinical, practical perspective, one diagnosis method is not possible, being recommended a constant assessment of certain signs (age, type of shoes used by the children, family and personal history, the children's age at the time when they first started wearing shoes, etc.) [3], [11, [17].

In order to establish a diagnosis as close to reality as possible, beside the complete and exhaustive anamnesis, the physical examination should be initiated with a global somatoscopic examination, then followed by a segmental examination, of the ankle and foot. Expressing his point of view on diagnosing flat feet, Mosca (2015), [30] also recommends attention in the assessment of feet deformities, emphasizing the idea that one must not focus solely on the feet.

It is well-known that the examination of the ankle and foot must be performed posteriorly, laterally, and anteriorly while the subject (the child) is in various static or dynamic positions (standing, sitting, walking).

Posteriorly, one can indicate the valgus of the calcaneus (in the posterior alignment of the foot one can observe the outer deviation of the calcaneus with the Achilles tendon).

Another approach in diagnosing was brought up by Yagerman et al. (2011), [49] citing the criterion "too many toes are seen". The aforementioned authors support the idea that a normal foot seen posteriorly allows only the visualization of the fifth toe, while in the case of a flat foot, it would allow the visualization of all toes.

A lateral inspection offers information on the medial longitudinal arch: in standing position, its height varies from light diminishes to touching the floor, and during sitting and walking, the medial longitudinal arch should regain its concavity, otherwise the foot is rigid.

To establish a diagnosis, Smits-Engelsman et al. (2011), [40] propose the examination of the generalized ligamentous laxity that can be highlighted through the hyperextension of the metacarpal-phalangeal joints, of the elbow or knee. The aforementioned experts also bring up the Beighton scale, with 9 points, a useful assessment instrument for joint hypermobility.

Next, there will be a review of the two aspects considered to be essential by experts when they approach the clinical-functional diagnosis: assessment of the medial longitudinal arch and of the eversion of the calcaneus / rearfoot valgus.

a) Assessment of the medial longitudinal arch

In determining the posture of the feet, most researchers have focused on the

assessment and measurement of the medial longitudinal arch. Studies by Mickle et al. (2006), [23] on new-borns and small children have shown that the medial longitudinal arch is covered by plantar adipose tissue, which makes the children's feet appear to be flat. This adipose tissue disappears between the ages of 2 and 5, as the aforementioned arch is formed.

Our review of the professional literature has led to the observation of two aspects:

- there isn't yet a temporal landmark that would indicate clearly, distinctly the age when the medial longitudinal arch stops developing;
- the process, however, stops in the first decade of the child's life, together with the bones, muscles and ligaments of the foot (Table 1).

Table 1

Synthesis of the experts' opinion regarding the age at which the medial longitudinal arch is developing

Age	Authors
2-6 y.o.	Shih (2012), [39]
3-6 y.o.	Staheli (1987), [42]
4 y.o	Clanțău (2019), [6]
5 y.o	Gould (1989), [15]
5-6 y.o.	Mortazavi (2007) [27]
7-9 y.o.	Tong (2016), [43]

For the diagnosis, the morphology of the medial longitudinal arch was assessed and measured over time using plantar prints, radiographic images, thermal, photographic, baropodometric or anthropometric measurements. Multiple articles reference the year 1928, when the researcher Schwartz evaluated the pathology of feet using plantar prints. Later, a variety of measurement were developed to determine the morphology of the feet and to diagnose the existing pathologies. After that, radiographic images allowed the investigation of flat feet by measuring multiple angles (the angle between talus and metatarsus 1 - Meary's angle, the angle between the plantar flexion of the talus and floor, and the talocalcaneal angle).

b) Eversion of the calcaneus or rearfoot valgus

The calcaneus position-flat foot relation represented another landmark for the diagnosis of flat feet in children. In 1937, Morton [28] put the bases for the conception that the foot functions optimally when the posture of the calcaneus is vertical.

Opinions presented in the literature regarding the diagnosis of flat feet in children indicate the following:

- a physiological adaptation of flat feet in children is that the eversion of the calcaneus is less than 10 degrees, otherwise the foot starts showing pathological traits;
- between the ages of 6 and 8, the calcaneal eversion is improved, and the

alignment of the forefoot is approximately parallel to the rearfoot;

- the eversion of the calcaneus is reduced by one degree every 12 months up to the age of 7 [47].
- between the ages of 6 and 16, the average calcaneal eversion is of 4 degrees (Sobel, 1999);
- Contrary to the aforementioned opinions, Mahan and Madden (2020), [22] state that the child's rearfoot at birth is in varus, suggesting that the eversion of the calcaneus in a closed kinematic chain is caused by the varus posture adopted in an open kinematic chain. In other words, these authors believe that the rearfoot valgus appears as a compensation mechanism of the rearfoot varus.
- Based on the founding of Morton (1937), [28] various experts used the position of the calcaneus to establish the posture of the foot. In this sense, flat feet were classified according to the angle gotten from the measurement of the resting calcaneal stance position-RCSP.

In close connection to the topic of our study, out of the desire to create a general standardized assessment framework, various experts conceived multiple evaluation instruments:

- FPI-6 (Foot Posture Index). This is an assessment instrument based on an individual 6-criteria score whose cumulated values determine the foot posture [26]: talar head palpation, evaluation of the supra and infra lateral malleoli curvature, eversion of the calcaneus, prominence in region of talonavicular joint, congruence of medial longitudinal arch, abduction/adduction of forefoot on rearfoot);
- FFP (Flat Foot Clinical Pathway or Proforma). This instrument records the significant clinical observations, such as arch for, range of motion, sensitive areas and waking, allowing for a more specialized diagnosis;
- p-FFP (Paediatric Flatfoot Proforma). This instrument is a revised version of FFP, created especially for the assessment of paediatric flatfoot. To ease the evaluation, p-FFP offers, according to Evans et al. (2009) [12], three possibilities to act, according to the type of flat foot (the color red indicates that the case needs treatment, yellow recommends monitoring the cases with asymptomatic flat feet, aged between 8 and 10, and green signals a normal development of feet in small children.

Analysing the advantages and limitations of the three instruments, Evans et al. (2009) [12], propose the use of FPI-6 for screening and p-FFP for classification.

Regardless of the instrument used, when analysing the paediatric flatfoot, one needs to differentiate between flexible and rigid flat feet.

F. The need to differentiate between flexible and rigid flat feet

This subsection highlights the three most used functional tests through which this differentiation is made:

- *Jack's test*. According to Mosca (2010) [29], this test is a way to assess the optimal function of the foot in a sagittal plane. In other words, the clinician dorsiflexes the hallux while the foot flat is on the ground, activating the windlass effect, and determining the tension in the medial longitudinal arch (if there is none, the foot is rigid).
- *The standing heel-rise test* functions also based on the previous principle. The basic action is that the child performs the plantar flexion by standing on her tiptoes,

using one leg. If the medial longitudinal arch appears, then the foot is flexible.

- *The Silfverskiöld test* was conceived for the assessment of the triceps surae muscle [45]. According to this test, if the dorsal flexion of the foot is lower than 10°, with a flexed knee, then the soleus muscle is contracted, and the entire Achilles tendon is retracted. If the dorsal flexion is higher than 10°, with a flexed knee, but lower than 10°, with an extended knee, then the gastrocnemius muscle is contracted.

The literature presents also other tests that can determine the aforementioned differences [20], [24], [31], but their presentation here would only state more of the same of what has already been told. It must be said, however, that there is no unity of ideas among the researchers.

3. Conclusions

Logically, as in any system, the function of every component determines its entire function, as a whole. In line with this logic, the function of the foot as a whole presupposes coordination, complementarity and association between the actions of all segments that compose it, which is why the modification of a single segment could potentially cause postural reactions in other segments, even inside the foot, as a whole. However, although many papers converge toward the clear manifestations of flat feet at certain ages, there is still no clear international consensus in regards to a standard assessment and measurement framework for flat feet in children.

Even though it was proven that in the first 10 years of life paediatric flatfoot is assessed by using certain norms, at a worldwide level the experts still do not agree how flat the foot should be in those years. This approach causes difficulties in the differentiation between the normal and the pathological variant of flat feet.

The researchers studied for this paper offered guidelines for measurement, various theories, assessment approaches and relevant scientific arguments, however it is still not possible to delineate a common line for standardization in regards to measurement and assessment. Most studies were also influenced by the method used to diagnose flat feet by the clinician, which leads to disparate values in regards to the prevalence of flat feet in children.

References

1. Atik, A., Ozyurek, S.: *Flexible flatfoot*, North Clin Istanb. Vol. 1, no.1, 2014, p. 57-64. doi: 10.14744/nci.2014.29292
2. Baciu, C.: *Anatomia funcțională a aparatului locomotor (Functional anatomy of the musculoskeletal system)*. București, Editura Stadion, 1972, p. 420-421.
3. Bleck, E.E., Berzins, U.J.: *Conservative management of pes valgus with plantar flexed talus, flexible*. In: Clinical orthopaedics and related research, Vol. 122, 1977, p. 85-94.
4. Bresnahan, P.J., Juanto, M.A.: *Pediatric Flatfeet-A Disease Entity That Demands Greater Attention and Treatment*. In: Frontiers in pediatrics, Vol. 8, 2020, doi.org/10.3389/ fped.2020.00019
5. Chen, J.P., Chung, M.J., Wang, M. J.: *Flatfoot prevalence and foot dimensions of 5- to 13-year-old children in Taiwan*. In: Foot & ankle international, Vol. *30*, no. 4, 2009,

p. 326–332. doi.org/10.3113/FAI.2009.0326
6. Clanțău, M.D.: *Corelații anatomo-clinice și imagistice în studiul bolții plantare pentru evaluarea tulburărilor de statică a piciorului (Anatomo-clinical and imaging correlations in the study of the plantar arch for the evaluation of static foot disorders)*. Doctoral Thesis, 4680, București, Facultatea de Medicină și Farmacologie Carol Davila, 2019.
7. Dare, D.M., Dodwell, E.R.: *Pediatric flatfoot: cause, epidemiology, assessment, and treatment*. In: Current Opinion In Pediatrics, Vol. 26, no.1, 2014, p. 93-100. doi.org/10.1097/MOP.0000000000000039
8. Didia, B.C., Omu, E.T., Obuoforibo, A. A.: *The use of footprint contact index II for classification of flat feet in a Nigerian population*. In: Foot & ankle, Vol. 7, no. 5, 1987, p. 285–289. doi.org/10.1177/107110078700700504
9. El, O., Akcali, O., Kosay, C., Kaner, B., Arslan, Y., Sagol, E., Soylev, S., Iyidogan, D., Cinar, N., Peker, O.: *Flexible flatfoot and related factors in primary school children: a report of a screening study*. In: Rheumatology international, Vol. 26, no. 11, 2006, p. 1050–1053. doi.org/10.1007/s00296-006-0128-1
10. Evans, A.M.: *The paediatric flat foot and general anthropometry in 140 Australian school children aged 7 - 10 years.* In: Journal of Foot and Ankle Research, Vol. 4, no. 1, 2011, p. 12. https://doi.org/10.1186/1757-1146-4-12
11. Evans, A.M.: *Screening for foot problems in children: is this practice justifiable?* In: Journal of foot and ankle research, Vol. 5, no. 1, 2021, p. 18.
12. Evans, A.M., Nicholson, H., Zakarias, N.: *The paediatric flat foot proforma (p-FFP): improved and abridged following a reproducibility study*. In: Journal of foot and ankle research, Vol. 2, 2009, p. 25. https://doi.org/10.1186/1757-1146-2-25
13. Ezema, C.I., Abaraogu, U.O., Okafor, G.O.: *Flat foot and associated factors among primary school children: A cross-sectional study*. In: Hong Kong Physiotherapy Journal Vol. 32, 2014, p. 13-20.
14. Farzin, H., Reza, M., Maryam, M., Ladan, A. Pediatric flexible flatfoot; clinical aspects and algorithmic approach. Iran J Pediatr., Vol. 23, no. 3, 2013, p. 247-260.
15. Gould, N., Moreland, M., Alvarez, et al.: *Development of the child's arch*. In: Foot & ankle, Vol. 9, no. 5, 1989, p. 241–245. doi.org/10.1177/107110078900900506
16. Gray, E.G., Basmajian, J.V.: *Electromyography and cinematography of leg and foot ("normal" and flat) during walking.* In: The Anatomical Record, Vol. 161, no. 1, 1968, p. 1–15. https://doi.org/10.1002/ar.1091610101
17. Halabchi, F., Mazaheri, R., Mirshahi, M., et al.: *Pediatric flexible flatfoot; clinical aspects and algorithmic approach.* In: Iranian journal of pediatrics, Vol. 23, no. 3, 2013, p. 247-260.
18. Haraldsson, S.: *Pes Plano-Valgus Staticus Juvenilis and its Operative Treatment.* In: Acta Orthopaedica Scandinavica, Vol. 35, no. 1-4, 1965.

p. 234-256. doi:10.3109/17453676508989356
19. Harris, R.I., Beath, T.: *Hypermobile flat-foot with short tendo achillis.* In: Journal Bone and Joint Surgery, Vol. 30 (A), 1948, p. 116-140.
20. Kwon, J.Y., Myerson, M.S.: *Management of the Flexible Flat Foot in the Child: A Focus on the Use of Osteotomies for Correction*. In: Foot and Ankle Clinics, Vol. 15, no. 2, 2010, p. 309-322. doi:10.1016/j.fcl.2010.02.001
21. Lupu, A.G.: *Studiu anatomoclinic al piciorului, din perspectiva antropologică (Anatomoclinical study of the foot, from an anthropological perspective)*. *Rezumatul tezei de Doctorat*. Facultatea de Medicină și Farmacologie Carol Davila, 2018, p. 37.
22. Mahan, K.T., Madden, C.M.: *Pediatric and adolescnet pes valgus deformity*. In: M. L. Butterworth, J. T. Marcoux (Eds.), The pediatric foot and ankle (1st ed., p.10). Springer Nature Switzerland AG. 2020, doi.org/10.1007/978-3-030-29788-6
23. Mickle, K.J., Steele, J.R., Munro, B. J. *The feet of overweight and obese young children: are they flat or fat?* Obesity (Silver Spring, Md.), Vol. 14, no. 11, 2006, p. 1949-1953. doi.org/10.1038/oby.2006.227
24. Miron, I., Miron, C.: *Semiologia aparatului locomotor (Semiology of the musculoskeletal system)*. Iași, Editura „Gr. T. Popa", 2005.
25. Morley, A.J.: *Knock-knee in children.* In: British Medical Journal, Vol. 2, no. 5051, 1957, p. 976–979. doi.org/10.1136/bmj.2.5051.976
26. Morrison, S.C., Ferrari, J.: *Inter-rater reliability of the Foot Posture Index (FPI-6) in the assessment of the paediatric foot*. In: Journal of foot and ankle research, Vol. 2, no. 26, 1957. doi.org/10.1186/1757-1146-2-26;
27. Mortazavi, S.J., Espandar, R., Baghdadi, T.: *Flatfoot in Children: How to Approach?* In: Iranian Journal of Paediatrics, Vol. 17, no. 2, 2007, p. 163-170.
28. Morton, D.J.: *Physiological considerations in the treatment of flatfoot.* In: Journal of Bone and Joint Surgery – British, Vol. 19, 1937, p. 1052-1056.
29. Mosca, V.S.: *Flexible flatfoot in children and adolescents*. In: Journal of children's orthopaedics, Vol. 4, no. 2, 2010, p. 107-121.
30. Mosca, V.S.: *Principles and management of pediatric foot and ankle deformities and malformations*. In: Wolters Kluwer Health, 2015, p.16
31. Moţet, D.: *Kineoterapia în beneficiul copilului (Corectarea deficienţelor fizice la copii*), revised. Bucureşti, Editura SEMNE, p. 119-120; 2011.
32. Peeters, K., Schreuer, J., Burg, F., et al.: *Alterated talar and navicular bone morphology is associated with pes planus deformity: a CT-scan study*. In: Journal of orthopaedic research: official publication of the Orthopaedic Research Society, Vol. 31, no. 2, 2013, p. 282-287. doi.org/10.1002/jor.22225
33. Pfeiffer, M., Kotz, R., Ledl, T. et al.: *Prevalence of flat foot in preschool-aged children*. In: Paediatrics, Vol. 118, no. 2, 2006, p. 634-639.
34. Popescu, A.N., Cotescu, E.: *Piciorul plat – privire de sinteza (Flat foot - synthetic look).* In: Revista Galenus, 2013, https://www.revistagalenus.ro/practica-medicala/piciorul-plat-privire-de-sinteza/- Accessed on 26.03.2020.

35. Pranati, T., Yuvraj Babu, K., Ganesh, K.: *Assessment of Plantar Arch Index and Prevalence of Flat Feet among South Indian Adolescent Population*. In: J. Pharm. Sci. & Res. Vol. 9, no. 4, 2017, p. 490-492.
36. Rao, U.B., Joseph, B.: *The influence of footwear on the prevalence of flat foot. A survey of 2300 children*. In: The Journal of bone and joint surgery. British volume, Vol. 74, no. 4, 1992, p. 525-527.
37. Rome, K., Ashford, R.L., Evans, A.: *Non-surgical interventions for paediatric pes planus*. In: Cochrane Database Syst. Rev. Vol. 7, 2010, CD006311.
38. Schwartz, L., Britten R.H., Thompson, L.R.: *Studies in physical development and posture. The Effect of Exercise on the Physical Condition and Development of Adolescent Boys.* In: Public Health Bulletin, Vol. 179, 1928, p. 124.
39. Shih, Y.F., Chen, C.Y., Chen, W.Y. et al.: *Lower extremity cinematics in children with and without flexible flatfoot: a comparative study*. In: BMC Musculoskeletal Disorders, Vol. 13, no. 1, 2012, doi:10.1186/1471-2474-13-31
40. Smits-Engelsman, B., Klerks, M., Kirby, A.: *Beighton score: a valid measure for generalized hypermobility in children.* In: The Journal of pediatrics, Vol. 158, no. 1, 2013, p. 119–123.e1234. doi.org/10.1016/j.jpeds.2010.07.021
41. Sobel, E., Levitz, S., Caselli, M., et al.: *Natural history of the rearfoot angle: preliminary values in 150 children*. Foot & ankle international, Vol. 20, no. 2, 2013, p. 119-125. doi.org/10.1177/107110079902000209
42. Staheli, L.T., Chew, D.E., Corbett, M.: *The longitudinal arch. A survey of eight hundred and eighty-two feet in normal children and adults.* In: The Journal of bone and joint surgery. American volume, 69, no. 3, 1987, p. 426-428.
43. Tong, J.W., Kong, P.W.: *Medial Longitudinal Arch Development of Children Aged 7 to 9 Years: Longitudinal Investigation*. In: Physical therapy, Vol. 96, no. 8, 2016, p. 1216-1224. doi.org/10.2522/ptj.20150192
44. Uden, H., Scharfbillig, R., Causby, R.: *The typically developing paediatric foot: how flat should it be? A systematic review.* In: Journal of foot and ankle research, Vol. 10, no. 37, 2017, PMC5558233
45. Ueki, Y., Sakuma, E., Wada, I.: *Pathology, and management of flexible flat foot in children*. In: Journal of orthopaedic science: official journal of the Japanese Orthopaedic Association, Vol. 24, no. 1, 2019, p. 9-13.
46. Ueki, Y., Sakuma, E., Wada, I.: *Pathology and management of flexible flat foot in children*. In: Journal of orthopaedic science: official journal of the Japanese Orthopaedic Association, Vol. 24, no. 1, 2019, p. 9-13.
47. Valmassy, R.L.: *Clinical biomechanics of the lower extremities*. St. Louis, Mosby, 1996, p. 246.
48. Wenger, D.R., Mauldin, D., Speck, G.: *Corrective management of pes valgus with plantar flexed talus*. In: Clinical Orthopedics, 1970.
49. Yagerman, S.E., Cross, M.B., Positano, R., et al.: *Evaluation and treatment of symptomatic pes planus*. In: Current opinion in pediatrics, Vol. 23, no. 1, 2011, p. 60–67. doi.org/10.1097/MOP.0b013e32834230b2