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Zastosowanie badania pedobarograficznego u dzieci – doświadczenia własne i przegląd piśmiennictwa

The use of pedobarographic examination in children – own experience and review of literature

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Streszczenie:
Pedobarografia jest nieinwazyjną metodą, która jest stosowana do opisu rozkładu nacisków na podeszwowej stronie stopy podczas stania i chodu. Znalazła ona zastosowanie nie tylko u dorosłych, lecz także wśród dzieci, służąc do oceny biomechaniki narządu ruchu, a w szczególności patologii stóp. Dzięki pedobarografii możliwe jest monitorowanie przebiegu oraz ocena skuteczności leczenia poszczególnych patologii. W poniższej pracy przedstawiono szerokie możliwości wykorzystania pedobarografii w diagnostyce i leczeniu schorzeń dotyczących narządu ruchu wśród dzieci, u których wszelako rozumiana terapia może przynieść często lepsze i szybsze efekty, niż u osób dorosłych.
Naszym zdaniem, pedobarografia powinna być stosowana powszechniej oraz częściej, i wspólnie z badaniami klinicznym i obrazowym, uzupełniać przeprowadzaną diagnostykę.

Słowa kluczowe:
stopa, diagnostyka, ciśnienie, chód, dzieci

Abstract
A non-invasive method, that can be used to describe the underfoot pressure distribution during stance and gait, is pedobarography. This examination helps to describe biomechanics of motor system, especially foot pathologies, among children and adults. It has been used to assess and monitor the progress and effectivness of undergone treatment. In this article we describe chosen issues of pedobarographic examination in diagnostics and treatment of the motor system in children, in whom an appropriate therapy can be more effective than in adults.
In our opinion, pedobarography should be used more often and widely than now. Together with clinical and radiological examination, it can simply complement standard diagnosctics.

Key words:
foot, diagnostics, pressure, gait, children

Introduction

The correct foot anatomy is of central importance to the mechanics of posture and gait. Pedobarography is the study of pressure fields on the plantar surface of the foot, during both: standing position for a period of time (static pedobarography) and gait (dynamic pedobarography). In addition, the posture pedobarography can be set apart, and this one would study the pressure fields on the plantar surface of the foot during a determined time of standing position. The tests may be carried out on the measuring devices, using the pressure-resistant in-shoe inserts, the isolated sensors and the tracks. Pedobarography helps to describe and diagnose pathologies of feet, talocrulal joints, but also knee joints, hip joints and spine, in the course of various system diseases and during the normal physiology of pregnancy. In orthopedics, the pedobarographic analyses are carried out on children as a diagnostic method, and to monitor the course of treatment in the foot pathology cases. Here it would be important to point out, that the tests on children often prove difficult, due to the lack of cooperation on their part during the proceedings. Sometimes a child happens to control the gait process visually, which brings about a variable gait length. The results

obtained in this manner would be divergent, so their interpretation would become difficult. Despite this, as a non-invasive method, pedobarography is being widely used in the locomotor apparatus biomechanics evaluation. [1, 2, 3, 4].

Foot defects commonly occur in children's pathology. They can be found in children otherwise healthy, as well as in those suffering other diseases or syndromes. The most common foot disorders referred to, are: flatfoot, congenital clubfoot and bunion [5]. The therapy here is based mainly on the initial conservative treatment, which includes i.a. kinesiotherapy, physiotherapy, or properly fitted orthotics. Only when this form of treatment remains ineffective, or shall there occur specific complications (for a considerable number of cases it would be the pain), the surgery is being recommended. In this article we will address potential use of the pedobarography for children. The selection of the articles we draw on is rather subjective, we just found them interesting, and they do emphasize pathologies most often related to children.

For the description of feet physiology and pathologies, while applying the pedobarography, it does prove useful to divide a foot into regions [3]. Currently used foot region classifications are: Blomgren's, Cavanagh's, Kernozek's and Stess's [6, 7, 8, 9, 10]. They make it easier to precisely describe the results. Otherwise, one should keep in mind the discrepancies between the anatomical and the clinical nomenclatures [11, 12]. It becomes profoundly evident, when it comes to determining parts of the midfoot region. The anatomic term "metatarsus" does not mean the same as the clinical "midfoot". In the first case, we have the area defined by the five bones of the metatarsus, while the second would be the stretch between the forefoot and the rearfoot, so it would be the sum of the LM an the MM regions – according to the Cavanagh's classification [3, 6, 7]. In translations, often only the term midfoot is being used, which leads to the ambiguous or the incorrect data interpretation. From the point of view of the descriptive anatomy, the term: midfoot would be closest in definition to the area, which may be described as the rear part of the metatarsus.

Pedobarography applications

Flatfoot, being one of the most common foot disorders, represents an issue which shall not be overlooked. In this case, pedobarography would be used, inter alia, to diagnose the defect. It appears, that pedobarography proves to be a better method than the graphic contour testing, especially with the obese children [13, 14]. Clinical evaluation of the flatfoot, in case of the obese children, is difficult and often unreliable. The body fat, located on the paracentral part of the foot, may be suggesting collapse of the longitudinal arch, thus leading to the false diagnosis. Impact of the obesity on the pressure pattern on the plantar surface of the foot. has been studied on children with the Down's syndrome – it has been shown, that the pressure pattern is affected not only by the child's obesity, but also by the child's sex. Children have also been studied to assess the results of the flat feet treatment they have received. The total of 17 patients (21 feet) have been examined, using the static and the dynamic pedobarography, and the imaging techniques. Researchers noted the improvement of the segmented foot position, of the side and of the paracentral pressure, and the decline in foot pressure pattern in the areas of forefoot and rearfoot. In the flatfoot disorder, surgical intervention should be restric-

ted only to the symptomatic patients, while in the case of children who suffer no pain – the conservative treatment is being recommended. Specifically in view of the fact, that the flatfoot defect tends to recede with age [17, 18, 19]. The pedobarographic analysis allows to correctly diagnose the defect and to monitor the process of its treatment [13].

Pedobarography, together with the medical imaging and the physical examination, constitutes a component of the clubfoot treatment results assessment [20]. With the use of pedobarography, the effectiveness of the posteromedial release could be confirmed. Cooper et al., have demonstrated in their study, that in the case of children with the unilateral clubfoot, the other foot also shows anomalies in the dynamic pedobarography test. They had set three study groups of children: the first group - children under the age of two, the second - between the ages 2 and 5, and the third - children older than five, and compared them with the control group of children with no clubfoot. Significant differences have been observed in the pressure patterns, the regularity in the initiation of the foot contact with the ground and the time period of this contact. In addition, they have demonstrated that these differences would evolve and change with age [22]. The study has also analyzed the effects of the non-surgical clubfoot treatment methods, such as the Ponseti technique and the French method. It has observed the reduced: peak pressure, maximum weight bearing and real-time pressure in the paracentral rearfoot, and the lower maximum weight bearing in the side of rearfoot – after the French method if compared with the Ponseti technique. Both methods though, in comparison with the control group, have shown the increased pressure and weight bearing, time of the foot's contact with the ground and the area of this contact, plus the time of the pressure in the side region of the rear midfoot. These values have been reduced in the first metatarsal region. The study has also observed the laterality of gait and the forefoot adductus [23]. Ponseti technique has been evaluated in yet another study. This one has shown the decrease of average peak pressure, pressure total time and average total maximum force in the forefoot and the rearfoot. The average total maximum force, and the pressure total time, have been increased in the rear part of midfoot. When comparing children with the unilateral clubfoot, decreased values of the average peak pressure in the paracentral region of the rearfoot and the forefoot, and in the toe area, have been observed [24]. The Ponseti technique, which has been compared with the surgical therapy of the clubfoot [25], is the most frequently used treatment method for this disorder – with proven effectiveness [26, 27], and the pedobarography, here as well, helps to verify diagnosis and to evaluate treatment.

High-arched foot may be a variation of the normal foot or a pathology case. It is often observed and associated with the Charcot–Marie–Tooth disease, and the proper treatment in childhood may prevent the further progression of this ailment [28, 29]. Because of the incidence rate of this disorder, it is important, that the dynamic pedobarography is used to compare results of the treatment in patients with the high-arched foot and the rearfoot motor dysfunction. A study has been carried out, in which one group has had osteotomy of the first metatarsal together with the soft tissue procedures in the paracentral edge of the feet, while the second group has had only the soft tissue procedures done. The study has shown an improvement of the pressure distribu-

tion pattern on the plantar surface of the foot – the rise of the maximum pressure on the first and the second metatarsal heads, and on the paracentral part of the heel bone – in the group where the two procedures have been performed [30].

Pedobarographic analysis has also been used to evaluate the biomechanical changes occurring among children with the foot axis distortion in the area of the tarsometatarsal joint. A group of 30 children has been divided into 3 sub-groups: the first one with the pronation, the second with the supination, and the third one – intermediate. In the first group, the study has determined the increased pressure in the paracentral and the rear part of the midfoot, the increased pronation and the outward rotation in the forefoot (outward forefoot adductus). The second group has shown the increased pressure on the side of the rear part of midfoot, the increased supination and the inward rotation in the forefoot (inward forefoot adductus). The third group has presented the increased and the evenly distributed pressure between the paracentral and the side part of the front tarsus, the increased pronation of the forefoot an the rotation of the inside of forefoot [31].

Both, static and dynamic pedobarography, have been used – to compare the pressure distribution pattern, the foot's contact area with the ground, the body weight bearing distribution along the lower limbs, and the incidence of the clubfoot alignment (in the plantar arch) of the gastrocnemius muscle complex, and of the gastrocnemius muscle with the soleus and the ankle joint – among the children with, and without the Sever's disease. It has come out that, in the second group, the maximum and the medium pressure on the ground, and the percentage of the body weight-bearing on each of the heels, has been higher. The clubfoot alignment of the gastrocnemius muscle and the ankle joint may constitute a risk factor for the occurrence of the avascular necrosis of the heel bone [32, 33]. On the other hand, pedobarography may be a valuable tool in the evaluation of the other risk factors, and the methods for treating, the Sever's disease.

In the case of children, cerebral palsy would be a major issue. It is well known, that it does cause disorders in the locomotor apparatus, and that most common of those are the defects of the feet [34]. These include: crooked, clubfoot and club-flat-crooked feet alignment, crooked ankle joints, plantar high arch and bunion, Combined with other examination techniques, pedobarography can be used for exploration, correct diagnosis of the disease, and to help choose the most appropriate treatment [35, 36, 37, 38]. Pedobarography has helped to confirm the effectiveness of the shock wave stimulation therapy on hypertonic plantar flexor muscles in children with cerebral palsy [39], and the effectiveness of the surgical treatment in children with the pes planovalgus disorder [40, 41]. In case of the latter, it has been established, however, that there is an additional risk of pain in the treated foot [41]. What's more, it has been proved, that the defect could be found in the unaffected foot of children with hemiplegia [42], and it has been established that the spastic diplegia can be found in children with HIV-encephalopathy [43].

Another study took a group of 9 years old girls with thoracic dextroscoliosis, and researched the impact of the ailment on the values and the distribution pattern of pressure on the plantar surface of the foot. It has observed an increase of the pressure in areas of the right forefoot and the midfoot, and in the area near the big toe on the left. However,

there has been a decrease of pressure forces in the midfoot area and under the heel on the right, and in the forefoot area, and under the heel on the left [44]. In growing up children occurs, and is considered normal, a voluntary turning of the forefeet inwards. If this disorder persists, the long-term problems may develop, namely the gait dysfunctions. Tibial osteotomy in children with biomechanical dysfunction symptoms does improve, but does not normalize, the pressure pattern on the plantar surface of the foot [45].

When it comes to children, the long discussed issue of the school backpacks carrying, does seem essential. A group of 218 children, 6-13 years old, has been examined during a normal day at school, and it has been established, that the pressure values on the plantar surface of the foot have increased, in posture and in gait, especially within the forefoot area. There is need to continue this research in future, to determine the long-term impact of weight-bearing on the biomechanics of the locomotor apparatus.

For children it has been determined, that there is no full symmetry in the pressure distribution between the right and the left foot [47]. As it turns out, several factors may influence the test results in this clinical research group. The first factor would be the child's age and the evolution of changes in the pressure pattern on the surface of the sole [48]. Lai YC et al., point out the necessity to take under consideration the foot progression angle in the pedobarography for children. The angle is, in fact, independent of age and sex, but it does influence the pressure of the foot exerted on the ground, and thus affects the pedobarography result [49]. The result may also depend on the gait speed. Pedobarography has been used to determine the changes in the children foot pressure pattern in relation to the gait speed. Similarly like in adults, the pressure is a subject to change and it is not uniform. During the rapid gait, pressure increases in the rearfoot, in its paracentral part and in the central part of the forefoot, and under the toes. The pressure decreases in the side part of the forefoot and the rear part of the midfoot [50]. In order to objectify the pedobarography results, a study has been done on a group of children 11 and 12 years old. By creating a space-time index an assessment can be made regarding the shift of the body weight on the plantar surface of the foot, which allows to eliminate this factor's impact on the result of the pedobarographic analysis and, in consequence, to increase the usefulness of the analysis [51].

Summary

To conclude, pedobarography is a non-invasive and a safe method, useful for case description, diagnostics and for treatment monitoring of the locomotor apparatus disorders. The above examples demonstrate its effectiveness, still it does seem to be used not often enough. In our view, pedobarography should be applied more widely and more frequently, and together with the clinical examination and the medical imaging, it should complement the diagnostics.

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