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# CORRECTION OF DEFECTIVE FOOT POSITION IN A PRESCHOOL CHILD – CASE REPORT

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***Abstract***

*The presented work deals with the topic of defective foot position in a preschool child and the possibilities of its correction. It takes the form of a case study, presenting the case of a preschool boy with a defective leg position and the content and results of the intervention that resulted in an improvement. The basis of the intervention was movement therapy, the potential benefits of which are often underestimated in practice, but a necessary condition for achieving them is the motivation of the child and his parents to carry it out regularly and methodically correctly.*

***Keywords***

*Defective position of the foot, flat feet in children, movement intervention.*

## 1. INTRODUCTION

We are witnessing in the world an increase in the number of lower limb diseases, defects and deformities. Especially in preschool age, we can observe an alarming incidence of flat feet. In the literature, this increase is reported to be as high as 95% (Novotná, 2001). The etiology is multifactorial, but hypokinesis and the higher prevalence of obesity in children play an important role (Levitová, Hošková, 2015). Adamec (2005) and Novotná (2001) list flatfoot as one of the most common diagnoses for which paediatric patients are referred to orthopaedic outpatient clinics.

Children's flat foot is a deformity that develops during the growing years. The exact cause is unknown, but obesity, malnutrition, prolonged bed rest or wearing inappropriate footwear may be involved. If the predisposed foot is loaded in this way, there is subsidence of the femoral head (plantar, medial), valgus heel and roll of the forefoot externally. Thus, the body's centre of gravity shifts to the inside of the foot and overloading occurs (Adamec, 2005).

The child's foot develops in terms of structures and function, even after the completion of verticalization. The bones do not reach their final shape until adolescence. Therefore, in the first year, we observe in children a physiological slightly varus position in the rearfoot, the forefoot in supination and a physiological buckling of the knees. With progressive growth and changes, around the third year, the heel position changes to valgus and the forefoot to pronation. By three years of age, valgusness up to 15 degrees is considered the norm. Buckled knees are physiological for this period. During growth, the limb axis flattens and the heel position should also flatten, only in larger defects does the concave or pronated position of the feet persist and the arch of the feet, therefore, does not develop (Levitová, Hošková, 2015).

*"The flatfoot in a child must always be placed in the context of the whole body. If the child is completely healthy and yet has a sagging arch, it is a primary flatfoot. But if the flatfoot is one of the manifestations of the overall disability, then we call it secondary flatfoot. Secondary flatfoot does not cause diagnostic confusion and there are more or less proven treatment procedures. Primary flatfoot, on the other hand, is a problem that is not resolved and in the approach to it there is no consensus.* (Teyssler, 2020, p. 35)

The most common symptoms that children complain of, are in most cases, post-load pain on the inside of the leg at the point of the hamstring tendon attachment tibialis anterior, on the outside of the leg below the ankle over the peroneal tendons and in the area between the ankle and the heel bone (Teyssler, 2020).

Flexible flatfoot in children is usually painless. Therefore, in most cases, children present for examination because of parental concerns about the appearance of their feet and/or

because of positive family history. The clinical evaluation of a child with flat feet should primarily focus on a general musculoskeletal examination (Mosca, 2010). Evaluate the condition of the foot can be assessed in a number of ways, some of which are very simple and can be done in the home environment. Conversely, more accurate examinations require modern instrumentation and expert evaluation. The basis of the assessment of the plantar surface of the foot is taking an imprint of the foot (Levitová, Hošková, 2015). The examination should begin with checking the wear pattern of the upper sole of the shoe. The physiological wear pattern should be around the posterolateral heel area, which is the area of initial contact with the sole at heel impact during gait. A child with a flat foot, however, may exhibit a posteromedial heel wear pattern (Turner et al., 2020).

The flatfoot can be examined with many tests, such as the heel rise test, jack test or Silfverskjöld test (Havlas and Teyssler, 2017).

During the examination, the stance and the way of walking should be further analysed, first in shoes and then barefoot. Particular attention should be paid to the assessment of heel valgus, the angle of progression of the foot and any rotational deformity. When observing from behind in the standing position, note the angle of the Achilles tendon near the abductor and also the alignment of the calcaneus.

Diagnosis is made by the physician from clinical examination and plantogram evaluation. X-ray of the foot is indicated only when the patient is in significant difficulty or if there is diagnosis confusion, especially with more severe pain lasting beyond rest and in relief, one must look for other causes of the difficulty (Adamec, 2005).

Podoscopic examination provides significant information. The podoscope is a modern diagnostic device that diagnoses orthopaedic foot defects. At durable acrylic plate with polarized light, defects of the small joints of the foot can be detected, the position, pressure and rotation of the heel bones and individual parts of the foot in relation to each other, as well as detecting defects in the axes of the ankle joints. On the basis of the pressure image, it is possible to assess the state of statics and dynamics of the feet. In the research related to this work, diagnostics were performed using the PodoCam device, which consists of two webcams and software. PodoCam allows the system to keep a patients record, take images and videos and compare the two examinations.

As with most orthopaedic diseases, the treatment options are conservative and surgical. Conservative treatment includes the use of orthotic insoles that help in supporting the arch and guiding the heel. Orthotic insoles do not serve to treat the foot, but only function as an adjunct to treatment and supplement in healing after surgery (Teyssler, 2020). The controversy regarding treatment procedures and especially the use of insoles is mentioned by Dungl (2014), who points out the careful consideration of any treatment for flat feet. He does not treat first and second degree flatfoot nor does he recommend orthotic inserts or shoe modification. As the most appropriate measure, he states barefoot walking, stretching (especially of the triceps calf muscle) and foot gymnastics, which takes the form of play, as the most appropriate measures. He also states that it is not necessary to prescribe physiotherapy in this case. In the third stage, orthopaedic insoles are already prescribed. Turner and colleagues (2020) mention physiotherapy as an essential element in the treatment, which eliminates muscle imbalances, activates flaccid muscles and stretches shortened ones.

Operative treatment is resorted to when pain and fatigue of the leg is prevented or when conservative treatment and therapy are ineffective. This type of treatment involves procedures on tendons, bones or a combination of both. Most children's flat feet will adjust spontaneously during growth as the hypermobility and maturation of ligaments. Teyssler (2020) states that although orthotic inserts are a widely used means of conservative treatment, they are often prescribed in a general and routine manner, yet the use of these aids is not necessary in every case. Thus, we often see children who wear orthopaedic insoles and do not need them at all, and conversely,

there are children whose findings signal a condition for a surgical solution, yet the only treatment tool is orthopaedic insoles.

*"In physical education and physiotherapy, we are based on the principles of sensorimotor science, i.e. on the fact that motor function is influenced by the sensations or information that the system receives. For us the most important in this respect is the exteroreception (the perception of information from the external environment, i.e. such as touch, pressure and heat) and proprioception (semi-sensation and movement, information from muscle spindles and Golgi tendon bodies). A sufficient amount of stimuli has a positive effect on the healthy development of the foot arch. Nowadays, the perception from the receptors is considerably dampened. Children wear inappropriate footwear and the plantar surface of the foot does not receive enough stimuli. For proper foot development, stimulation of the foot with an optimal amount of different stimuli is essential.*

*This is called exteroceptive and proprioceptive stimulation, or the use of receptor facilitation (from the sole of the foot), which can be done in several ways."* (Levitová, Hošková,2015, p. 97)

Barefoot walking also stimulates the function of the sole of the foot. Levitová and Hošková (2015) recommend walking barefoot on grass, stones, sand, in the forest, paddling in the water and walking on slippery or rough surfaces. Even in the home environment, there are options for stimulating the sole of the foot. For children, a fun form is suitable. Sensory carpet or orthopaedic flooring or home-made aids are suitable. Barefoot foot cushioning is also recommended.

Levitová and Hošková (2015) also recommend relaxing the skin and subcutaneous tissue of the foot. Foot massages, pressure segmental massages and massages with a special ball, called a hedgehog, are used for relaxation. Mobilisations of the small joints of the foot can also be included. After relaxation, there are significant changes in the sensation of the leg, due to the blood supply to the short muscles.

Regime measures are an important part of prevention. Levitová and Hošková (2015) include: sufficient exercise in the toddler, preschool and school periods, healthy footwear for children, choice of adequate socks, the elevation of the lower limbs to reduce swelling in the ankles and on the dorsum of the foot, correct ergonomic principles of sitting, elimination of factors contributing to flat feet (weight reduction, sufficient physical activity, limitation of permanent avoiding prolonged standing, prolonged walking with inappropriate loads on hard ground and walking in inappropriate footwear.

Some experts also recommend taping. By using functional taping, we can increase the support of the transverse and longitudinal arches of the foot. A taping at the transverse arch of the foot helps the coordinated activity of the short muscles and all the toes towards flexion and abduction. It also promotes the active creation of the transverse arch by supporting the last links of the toes and conforming to the surface (King, 2020).

The basis of movement intervention is health compensatory exercise. The aim of these exercises is to promote the correct function of the short leg muscles and to maintain or increase the mobility of the leg joints. During the exercises, it is important to focus on stimulating the transverse and longitudinal arches of the foot, strengthening the muscles of the plantar foot, restoring flexion and dexterity of the toes, strengthening the LL muscles, stimulating balance with maintaining an upright posture, and generally counteracting permanent deformities (Levitová and Hošková, 2015).

Levitová and Hošková (2015) divide these exercises into several areas, namely the initial warm-up of the feet in standing – walking (on the toes, heels, on the pinky side of the foot), rocking from toes to heels, "caterpillar", relaxation exercises in sitting – movements in the ankle joints, movements of the toes, training of the grasping ability of the chest and feet – picking up objects, drawing on paper, unfolding and folding a towel with the toes, using an obstacle course – stepping on sticks, walking over various objects, practicing proper unwinding of the foot from the mat – practicing accurate footing, feeling the three-point foot support, stabilizing the foot on an unstable surface – balance training, training without visual control, pelvic stabilisation and corrected posture and sensorimotor exercises – foot facilitation, training of pressure distribution on the foot, training of three-point

support in standing and walking, stabilisation of the foot on a labile surface (the limitation of these procedures for children lies in the risk of misunderstanding the procedure).

## 2 AIM OF THE WORK

The aim of the work is to analyze the condition of the plantar foot in a case study of a selected preschool child and to monitor and evaluate changes before and after the application of the indicated procedures using podoscopic examination.

## 3 METHODOLOGY OF THE WORK

The method used was the diagnosis and correction of defective foot position in a selected individual aged 5 years. The diagnosis was performed using a plantoscope (PodoCam 2.0) and standing static examination on two Tanita scales. Mayer's line and segmental methods were used to assess the arch of the leg. The correction was performed using selected exercises and regimens that focused on the deep spinal stabilization system (DSSS), valgus knee position, ankle stabilization, and flat foot. Exercises were selected according to the difficulty and age of the proband, i.e., primarily in a lighter and more fun form. Each stack of exercises was modified depending on the results of the proband's continuous flatfoot measurements.

## 4 CASE REPORT

### Medical history

- Personal history

Gender: boy, age: 5 years

Motor milestones – no difficulties, independent walking at 12 months, very frequent use of hanging "bouncer" (risk factor for flatfoot).

History of falls – no difficulties, on the contrary, lower incidence of falls.

Foot and leg pain – around the second year, pain occurred with longer distances, cause not determined.

First podiatric examination at age three. A toe-to-toe gait with a wider base, a symmetrical lying posture, buckled knees, all joints with normal mobility, and a flatfoot, partly still infantile, was found by plantoscopy. The examination also revealed subtalar pronation of about 14 degrees and severe impairment of body stability. The doctor shaped the half-pads.

4 years – after further examination, heel eversion was detected and the half-pads had to be reshaped.

5 years – a follow-up examination was performed and the lying posture was still symmetrical, the length of the limbs was identical, the arches of the feet were formed, the mobility in the joints and the gait were normal. Suspected slight external rotation in the right hip joint. Plantoscopic examination confirmed mild varusity of the right foot with adduction of the big toe.

- Family history

Mother hip dysplasia (treated at an early age – cured), father flatfoot (untreated).

Mother's father thoracic kyphosis, valgus knees.

- Work history

At the beginning of the investigation the proband was a preschooler and at the end already a primary school pupil.

- Social history

He lives with his parents and siblings in the family home.

- Sports history

Swimming from 6 months to 4 years. From 1.5 years to 5 years old exercise for the little ones (motor versatility). Since 3 years old, regular lessons every winter weekend on downhill skis with an instructor. From September 2021 (from 6 years old) he started playing ice hockey.

- Rehabilitation history

Physiotherapy not indicated, but special orthopaedic aids are used and he tries to go barefoot as much as possible in the summer months. Since the age of 3 he has specially shaped half-pads which are changed every six months.

- Current medical history

Flexible infantile flatfoot, body stability disorder, subtalar pronation in the ankle joint.

- **Aspection and examination of the function DSSS (Deep spinal stabilisation system)**
  - standing examination: standing on a narrower base of support, the left shoulder blade is higher and further away from the spine and protrudes, asymmetrical shoulder position – left shoulder is higher, valgus knees, subtalar pronation at the ankle joint, tip rotation and marked valgus knees during gait.
  - DSS examination: unsatisfactory result, abdominal wall prominence – weakened DSSS.

## INPUT MEASUREMENT

Input measurements were performed with the selected proband on February 5, 2021. In addition to the aspectual assessment, we measured the symmetry of body weight distribution on two Tanita scales and examined the position of the sole of the foot on a PodoCam podoscope. On the podoscope we observed the flatfoot in free standing position, squatting and single leg standing on the right and left leg. The webcams on the PodoCam allow us to view the foot from below and the heel and ankle joint position from behind.

### Tanita scales

Already according to the results of the examination of the aspects we could expect a significant load on the right side of the body, which was subsequently confirmed. The weight on the left side was 10.2 kg and on the right side 13.9 kg. The difference was 3.7 kg and with the proband's weight, it accounts for 15% of the weight difference. We evaluate a very significant difference in loading and therefore a significant disturbance of the orthogonal statics of the body.

- Podoscope

According to the photographs taken from the PodoCam examination, it can be seen that the proband is loading the forefoot more than the rearfoot. From Kapandji's (1985) visual scale, a more pronounced flatfoot on the left foot and a milder flatfoot on the right foot can be confirmed. Looking at the free standing from behind, we can notice the eversion of the heel. This examination is further evaluated using Mayer's line and segment method.

In squatting, i.e. with a higher load, the knees go into a more valgus position and the weight is transferred to the medial side of the foot. In the single leg stance, the weight distribution is shifted to the medial side. Proband had difficulty maintaining stability on one leg, which is to be expected by the given history.

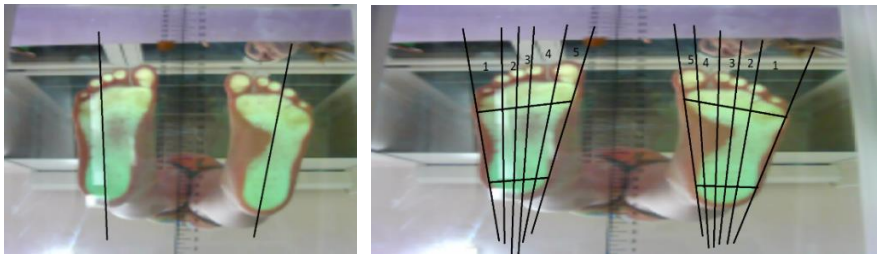
From the plantogram evaluation using the Mayer line, a higher degree of flatfoot. On the right leg, on the contrary, the foot is normal at the segmental interface arched foot and grade 1 flatfoot. In the second method of assessment, the plantogram of the left foot into the fifth segment, which is classified as grade 2 flatfoot. The right leg is on the borderline between the normal arched leg and grade 1 flatfoot, as has already been shown at the Mayer line.

***Figure 1 Initial Aspect Examination***

***Figure 2 Measurements on the podoscope***

***Figure 3 Input measurement on podoscope – free standing position***

***Figure 4 Input measurements – Mayer line and segment method***



## Description of the intervention

Due to the situation regarding the ongoing Covid-19 pandemic, the proband conducted the first part of the intervention independently with the parents in the home environment for six weeks, i.e. from 16 February 2021 to 24 March 2021, when a personal visit took place. We reviewed the exercises, modified and corrected the execution, and added a new stack. We also appealed for foot stimulation in the home environment (orthotic discs, barefoot walking). The parents tried to exercise regularly every day with the proband.

**The first stack of exercises** focused mainly on flat feet and DSSS. Orthopedic aids and body weight were used.

1. Orthopedic discs: used to walk on tactile discs in the form of a game. The boy named the discs according to their shape: hedgehog, freckle, cushion and ladybird. The discs were used several times a day, first for classical walking or in modifications (blindfolded guessing using only the feet).
2. Lion walk: a slow gait in which the foot falls first on the heel, over the little toe edge and the weight is transferred to the whole foot.
3. Roller: massaging the feet with a special ball "hedgehog".
4. Lifting objects involving the LL toes: the proband's task was to lift a soft ball or other object using only the toes of the foot (activating the longitudinal arches).
5. Horse: changing position from flexed toes to heels (activating the foot).
6. Object sliding: while seated, sliding a heavy object with the outside and then the inside of the foot.
7. Teddy bear: exercises to strengthen DSSS, in a kneeling position the boy slowly lifts his knees off the ground and then slowly brings them back down (teddy bear). In the same position, the boy alternately lifts the LL (teddy bear lifts the foot).
8. Baby: pushing into knees in supine position with legs at right angles (DSSS activation).
9. Pushing into the knees: while seated, proband raises one leg and the opposite arm and pushes the palm of the hand into the inside of the knee.
10. Counter-pressure of the toes in sitting.

**The second stack of exercises** focused not only on flat feet, but also on modifying the function of peripheral structures. For the DSSS strengthening exercises, equipment common in every household and BOSU were chosen. This stack of exercises was performed from March 25, 2021 until the first interim measurement, June 24, 2021.

1. Fluent walking on heels and toes.
2. Barefoot walking.
3. C-arch – transverse arch release: massage of the transverse arch, which the proband can do on his own or parents can join in.
4. Massage of the longitudinal arch of the foot (activation of the foot arch).
5. Caterpillar: toe flexion and straightening.
6. Broomstick walking (exercise targeting the longitudinal and transverse arches).
7. Standing one-legged on BOSU: proband steps off the ground with right/left foot on BOSU and bends the other leg in front of the leg. In this position he maintains stability.
8. This exercise is used to improve the overall stability of the body.
9. Candlestick: standing slightly straddled, tighten palms up, rotation.
10. Kneeling on the BOSU: kneeling on a balance apparatus, the boy alternately kneels on the LL.
11. Collecting sponges in bowls: bowls according to size and dish sponges were placed in front of the proband, his task was to grasp a sponge with one foot and place it in the bowl. A modification was a variant with the sponges placed on the foot.
12. Stepping on orthopaedic discs. Used to practice and maintain balance and activate the longitudinal and transverse arches.

**Interim measurement**

The first interim measurement on the podoscope was on 24 June 2021. As the examination was four and a half months later and we had rotated two stacks of compensatory exercises, we felt it appropriate to check whether the static body condition of the plantar foot had improved. Intentionally, this measurement was made before the holidays, as we left the boy without exercise for the following three months and we introduced only regimen and peripheral structure adjustments before he started another new set of exercises with the start of the school year.

- Tanita scales

A slight improvement was noted. We measured a weight distribution of 11.1 kg on the left half of the body and 12.9 kg on the right half. The difference was 1.8 kg, with the proband's weight accounting for 7.5% of the weight difference. Thus, we evaluate the difference in load with a more moderate deviation, and therefore, from our point of view, a significant improvement in right body statics.

- Podoscope

There was also a slight improvement. It is observed mainly in the one-legged standing position, especially on the left leg. Also, there is an improvement in aspectively assessable standing stability and posture of the proband.

***Figure 5: Interim measurement on podoscope – free standing position***

**Regimen modifications**

From June 25, 2021, we left the proband without a stack of compensatory exercises (holiday period) and focused only on regimen modifications and foot stimulation. Throughout the three months, the parents tried to make the most of barefoot walking on different terrain (pebbles, sand by the sea, grass) and foot hardening. We kept only orthotic discs and massage.

**Exercise stack**

In the next period, this third stack was followed by exercises for the flat foot, DSSS and to improve the valgus position of the knees.

1. Beatle with a ball. The boy lies on his back and rotates the gymnastic ball with the help of his arms and legs (strengthening DSSS).
2. Stability on the ball. Proband sits on the gymnastics ball and his task is to take off his socks using only his feet and then grasp the sock, lift the LL and still maintain stability on the ball.
3. Moving objects on all fours.
4. Circling feet with toes together and then vice versa.
5. Caterpillar.
6. Walking on a broom.
7. Roller.
8. Rolling the toes of the feet while lying down. Exercise for valgus position of the knee joints.
9. Orthopedic discs.
10. Bow tie. Pushing the knees to the mat in a squatting position, feet together (exercise for valgus position of the knee joints).
11. Drawing. The proband's task was to draw a picture with the right and left foot.
12. Alternating toe and heel positions.
13. Barefoot walking in the home environment.

It is important to mention that since mid-September the proband started playing ice hockey, three times a week.

**Output measurement**

Output measurement took place on December 21, 2021. Since the proband started to play ice hockey when he entered primary school, the parents and the boy did not have much time for compensatory exercises and regimen adjustments. Thus, the exercise stack was not filled as faithfully as in previous months.

- Tanita scales

Since the beginning of the introduction of the exercise stack, we have given sufficient attention to strengthening the DSSS, therefore improvements in body weight distribution can be expected. There has been a significant improvement. The weight distribution is 12.5 kg on the left half of the body and 12.6 kg on the right half.

Therefore, the percentage difference in right-sided loading is negligible with a 0.1 kg difference in proband body weight, and significant improvement and resultant symmetry in right-sided loading of the lower limbs can be confirmed. Aspectively, there was also an improvement in the stability of the body during walking and a reduction in valgus knee position.

- Podoscope

When comparing the photographs from the first measurement to the final one, we could notice a significant improvement. Unfortunately, since the interim measurement, the photographs show a deterioration of the plantar flexion of the feet, both in free standing and in single leg standing on the left leg.

In the outcome assessment, deterioration of the plantogram can be clearly observed and is demonstrable in both methods. The left leg is clearly classified as grade 2 flatfoot. On the right leg, there is a clear weakening of the longitudinal arch, which extends to the border between the 3rd and 4th segments. However, the right leg is still classified as grade 1 flatfoot.

The deterioration in the plantogram assessment can be attributed to the sport the boy has taken up. Irregular exercise will also contribute to the deterioration of the foot. Ice

hockey should be viewed as a sport that may be a risk factor in the development of flat feet. The pitfall is the skate itself, which is very rigid and does not allow much movement at the ankle joint, and there is no natural rolling of the foot during the skating stride.

***Figure 6 Final measurement on the podoscope – free standing position***

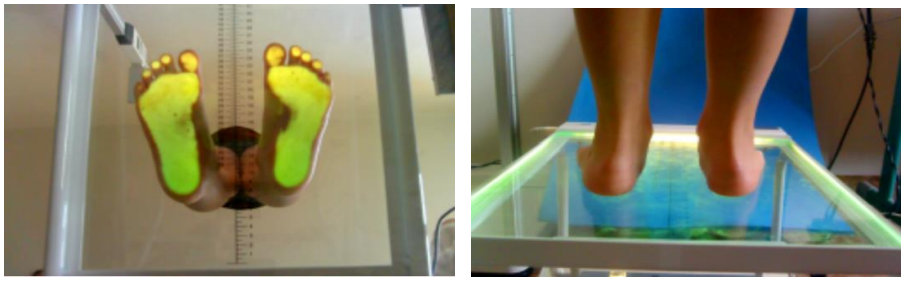
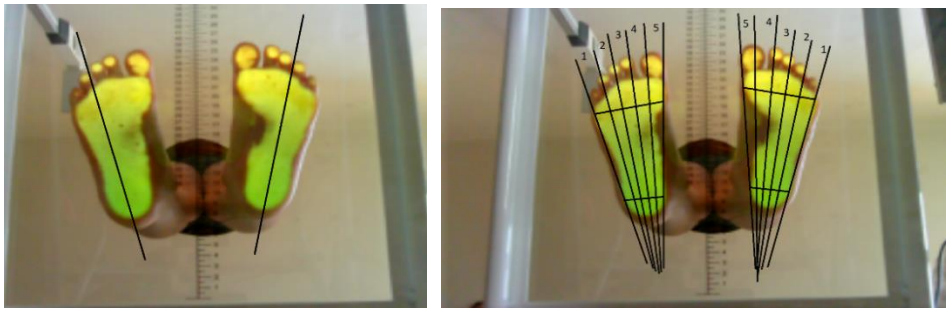


***Figure 7 Final evaluation – Mayer line and segment evaluation method***



## DISCUSSION AND CONCLUSION

The presented case report shows that the influence of movement intervention and regimen measures can achieve correction without the need for orthopaedic insoles or other special shoe modifications. Its benefits are often underestimated in practice, but a necessary condition for their achievement is the motivation of the child and his/her parents for its regular and methodically correct implementation. If the exercises are not regularly performed and the regimen is not followed, their effect will diminish. Other influences, such as inappropriate sporting activity, may also negate the positive effect of the intervention.

The choice of an appropriate approach to flatfoot is based on a precise differential diagnosis. The musculoskeletal system should be viewed as a whole, and although a functional disorder may have a primary cause in a specific segment, it will always affect the function of the system as a whole. What is significant, therefore, is whether the flatfoot is primary or secondary and we approach its management accordingly. However, movement therapy is always part of the treatment approach, as are regimen measures. Ideally, they should also be part of primary prevention, which in our environment is usually carried out within the framework of health physical education.

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