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THE ACTIVE DETECTION AND CORRECTION OF THE FOOT POSTURE MODIFICATIONS IN CHILDREN

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Abstract

The effects of postural modifications and musculoskeletal disorders represent the main reasons for reduced productivity and a significant decrease in the quality of life. For over 80% of the population, there is a prevalence regarding the dysfunctional legs. These problems, which in most cases begin in childhood, aggravate over time and the possibility of correction becomes impossible. During the child's development, there are certain aspects or postures of the lower limbs considered as "physiological", which are often transient and do not have a pathological significance. Generally, we spend approximately 99% of the time walking or in an orthostatic position on hard flat surfaces, mostly using inappropriate footwear, which aggravates this problem. The purpose of this paper is to initiate a study regarding the effects of applying a physiotherapy protocol associated with medical insoles for the foot posture modifications in children. The participants were 27 subjects aged between 6 and 16, who followed a physiotherapy protocol according to the subjects' needs determined on the basis of a functional assessment. The monitored parameters were the pain and the plantar support area. We used a visual analog scale for pain and a pressure plate to assess the plantar support area – Presscam V 4. The statistical processing of data obtained highlights a significant decrease in pain for all subjects.

Keywords: Foot posture, medical insoles, physiotherapy, quality of life.

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1. Introduction

Currently, the posture issues are of great importance, and this is the result of contemporary society. It is estimated that approximately 75% of the planet's population suffers from a modification of the foot posture - excessive pronation due to the tibial varus factor, as well as the hard flat surfaces on which we walk every day (*Vasyli Medical*, 2016). Excessive pronation mostly affects the normal function of the knee and the hip alignment, and increases the back muscle forces. These biomechanical changes are common to most people, from children to adults or elderly people, from athletes to persons with a sedentary lifestyle.

In order to solve problems related to health preservation and strengthening, we believe that it is necessary to know and consider the biological changes occurring in the body during the growth and development period. The use of medical insoles for correcting the foot biomechanics cannot be approached without a complex study, the knowledge and strict observance of the growth and development particularities of the musculoskeletal system.

2. Problem Statement

The foot represents the lower limb's terminal lever that connects the human body to the ground during current biomechanical actions. The existence of the plantar vault is specific to the bipedal position of the human body, which can be compared to an architectural vault. It can support its own weight and the weight added by the shape and layout of the component parts.

During the walk, after the calcaneus touches the ground, the plantar niche is formed, wherein the nerves, vessels and muscles are protected against pressure. The skeletal structure bears variable loads due to the body weight, therefore the force lines and the support points are permanently changing. The plantar vault supporting the joints is represented by interosseous ligaments and muscles. The articular surfaces are maintained in contact with the internal or external ligaments, and the foot, as a terminal segment of the lower limb, has a number of 32 joints.

When the lower limb acts as a closed kinematic chain, with the foot in contact with the ground, the calf segment acts as a first-degree lever, whose support points are located on the phalanges of the foot, with the body weight as resistance and the foot extensors as force. In this situation, in order to maintain the lever's balance, the tibia will bear forces of approximately 1000 N, which may increase up to 5000 N if the walking propulsion occurs, involving dynamic strain in order to overcome the gravitational force. When the lower limb acts as an open kinematic chain or when the foot performs the flexion motion, the calf acts as a third-degree lever, a speed lever.

The performed studies underline that, by the lower limb realignment with the help of medical insoles, the correct function of the foot is ensured, which helps to eliminate/ameliorate the most common problems of biomechanical origin. In association with physiotherapy programs (kinetotherapy, electrotherapy etc.), medical insoles prevent the onset of vicious positions or lead to the correction of certain foot posture modifications.

In two studies, Dr. Rothbart included 500 subjects (adults of different ages) suffering from chronic back and knee pains. They initially claimed that they had to learn to live with the pain; after one year

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during which they used medical insoles, over 70% of the study participants reported a significant reduction of the pain (Posture Dynamics, 2015a).

Another study identified 38 articles from different specialized journals, which aimed to assess different situations regarding the foot biomechanics (the effect of the foot posture modification, the use of medical insoles or different types of footwear) and electromyographic changes (EMG) or magnetic resonance (RMN) in the lower limb muscles, which might occur during walking or running (Murley et al., 2008).

The results of these studies highlight that the EMG of the lower limb muscles show variations according to the modifications of the foot posture in the case of using medical insoles or inappropriate footwear. The studies underline that: the foot in pronation causes greater activation of the muscles that perform the inversion foot motion and low activation of the muscles performing the eversion foot motion; medical insoles determine an increase in the activation of anterior tibial and long peroneal muscles and can modify the posterior muscle activation; the high-heeled footwear modifies the activation of the posterior leg muscles.

3. Research Questions

The connection between the foot biomechanics and posture does not benefit from major attention in medicine. Generally, the impact of foot biomechanics on posture continues to be considered a problem which is not properly shaped. In orthostatism, the ground reaction forces are directed upwards against the plantar surfaces of both feet, by keeping in a transverse plane the balance and stability of the lower extremities and pelvis. The ground reaction forces are equally exerted on the lateral and medial plantar surfaces of both feet. When the torso is rotated to the right, the right foot is in supination and the left foot, in pronation. For the right forefoot, the ground reaction forces are inverted. The vertical reaction forces are higher on the lateral part of the forefoot and smaller on the medial part of the forefoot. When the left forefoot remains on the ground, the vertical reaction forces are evenly distributed on the forefoot. When the torso is rotated to the left, the ground reaction forces exert unequal forces against the left forefoot and equal forces against the right forefoot. (Magee, 2008, p. 853)

Pronation of the foot within normal limits is initiated at the hip level in order to unlock the foot that prepares to start walking, which allows the foot to attenuate the impact. Hyperpronation originates in the structure of the foot skeleton, causing the collapse of the longitudinal arch and the inward rolling of the ankle when the foot supports the weight. Hyperpronation causes an internal rotation of the lower extremities. Due to the fact that the left foot has more pronounced hyperpronation than the right foot, this asymmetry of the internal rotation usually causes a forward and downward dislocation of the left pelvic bone, which is higher than the right pelvic bone, causing the pelvis imbalance and a discrepancy in the length of the lower limbs. As these cascade dislocations elevate the axial frame, the scoliosis and kyphosis curves are exaggerated. The rib cage usually twists counter-clockwise, the left shoulder continues the motion usually more than the right one, so the right shoulder falls down. The jaw moves towards the anterior part causing a change in mastication. These modifications also lead to the anterior dislocation of the gravity centre of the body, causing high strain on the forefoot and an increased muscle

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activity in order to maintain balance and stability. If this collapse occurs, the health consequences are significant. (Posture Dynamics, 2015b)

The child's body differs from the adult's body through a series of particularities regarding each organ and structure and function of the system, as well as of the entire body. The results of research conducted in the fields of morphology and physiology reveal that the growth and development processes are not anarchically and accidentally, identically and uniformly performed at different ages. Each organ, each system grows and develops according to the "laws of growth and development". The younger the age, the more the child's growth and development processes intensify.

The child exhibits certain particularities related to the musculoskeletal system, which may generate advantages, such as an extraordinary healing capacity and the fact that fractures hardly occur in children due to their bone elasticity, but also disadvantages, such as the emergence of abnormalities in the development of the musculoskeletal system if certain components of the child's skeleton are affected.

Morphofunctional growth differs according to gender. Both the morphological indices (waist, mass, thoracic perimeter) and functional indices (vital capacity of the lungs, muscular strength, metabolism, energy consumption) are lower in girls than in boys from birth to the prepubertal growth occurrence. In girls, the prepubertal period starts early, at the age of 10-12, when the growth and development processes intensify, which results in a staturo-ponderal level at the age of 12-13, exceeding the boys' level. When boys reach the prepubertal phase, growth is intensified and therefore, at the age of 13-14, they exceed the girls' staturo-ponderal average level, which is also maintained at the adult age.

A study performed in 1996 shows that mechanical factors strongly influence skeletal ossification and intervene in the regulation of changes in bone geometry and apparent density during ontogenesis. Computerized models have been developed for this purpose, consisting in the implementation of a simple mathematical rule relating to cyclic tissue tensions to bone apposition and resorption. Since the foetal stages of the femoral anlage, these models successfully predict the bone growth and modelling observed in the development of the diaphyseal cross section (Carter, Van der Meulen, & Beaupre, 1996).

The development of the body occurs under the influence of the biological, environmental and social factors. This issue of the biosocial correlation between the individual's growth and development is very complex and poorly studied. Each body has its own genetic growth and development programming (rhythm of growth, order of maturation of the organs and systems, sexual dimorphism, biological endurance), whose accomplishment is accelerated or slowed down by the action of environmental factors.

In the last 3-5 decades of the twentieth century, there was an intensification of the child growth and development. This phenomenon, encountered and recognized in children of all ages and nationalities, is called "acceleration". The essence of this acceleration consists in the fact that, due to the intensification of the growth and development rhythm, the biological maturation stage ends at an earlier age compared to previous generations. The acceleration rhythm varies at different ages, and the most intense one corresponds to adolescence. This phenomenon also occurs in the musculoskeletal system, in the sense that the skeletal ossification rhythm is accelerated and the tubular bone ossification ends sooner.

The mentioned divergence of opinions confirms that there is no unique concept yet, although most authors believe that the phenomenon of accelerated growth and development is mainly caused by the complex interaction of the environmental and social factors with the human body, thus contributing to essential changes in the biological process.

Considering the above aspects on the features of growth and development of the musculoskeletal system, we consider it important to approach certain decisions regarding the prevention or therapy of the biomechanical or posture problems of the foot according to these aspects.

4. Purpose of the Study

The purpose of this paper is to initiate a study regarding the effects of applying a physiotherapy protocol associated with medical insoles for the foot posture modifications in children.

5. Research Methods

The study was conducted over 2 years, 2015 and 2016, on 27 children aged between 6 and 16 years. The results achieved following the assessments and reassessments, at a 6-month interval, were statistically processed using the T-test of the Excel 2010 software. The study took place at the Kinetic Sport & Medicine Clinic, and the tested parameters were represented by pain and the plantar support area.

The pain assessment was performed using a visual analog scale, which is a visual numerical scale consisting of a horizontal ruler with anchors at both ends. The ruler is marked from 0 (without pain) to 10 (severe pain). To assess the intensity of children's pain, a pain scale through the face expressions was developed. It consists of 6 schematic faces illustrating the increase in pain severity expressed by mimics and is associated with faces from 0 to 6 (Bieri et al., 1990). This is a valid and reliable evaluation instrument that can also be used for the elderly (Rodriguez, 2001).

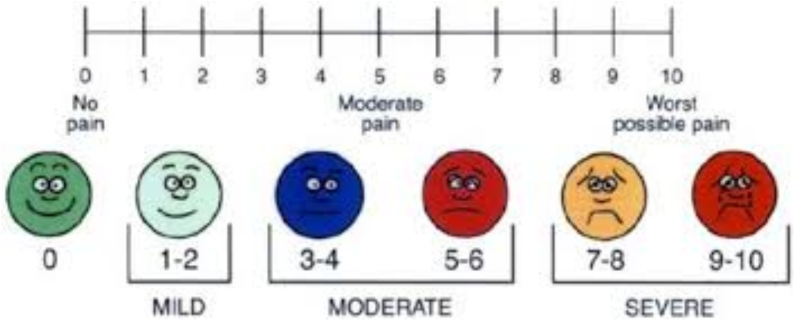

Figure 01. Visual Analog Scale (VAS) for pain

The plantar support area was assessed using a pressure plate – Presscam V 4. This is a hybrid of the pressure platform for posturology, according to the Directive 93/42/EEC, certified by DEKRA. It features a state-of-the-art software tool (power supply by USB cable), with new functions and presentation modes. Seven parameters can be viewed and analysed by using this device; in this study, we analysed the plantar support area by the anterior left, right and posterior left, right components.

Following the initial evaluation, medical insoles associated with a customized physiotherapy protocol were recommended for each subject according to the needs determined within the evaluation, and after 6 months, the subjects were reassessed by complying with the conditions of the initial evaluation. The rehabilitation goals are strength and flexibility. Strengthening the muscles that support the

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lower leg, foot and ankle will help keep the ankle joint stable. Stretching the muscle is important for restoring the range of motion. The muscle groups of the lower leg targeted in this protocol, as well as the tendons and ligaments that control the foot movement include: the gastrocnemius-soleus complex, anterior tibialis, posterior tibialis, peroneus longus and peroneus brevis. Performing the program 3 to 5 days a week will maintain strength and the range of motion in the foot and ankle (American Academy of Orthopaedic Surgeons, 2016).This program should be continued for 4 to 6 weeks, under the supervision of a physical therapist.

6. Findings

The data achieved following the evaluations aimed to underline the evolution of pain were summarised, analysed and graphically represented (Figure 02). Thus, an important decrease in the intensity of pain has been highlighted: from an initial average of 7.630 points, the final evaluation reveals an average of 3.148 points. Since the pain assessment method is subjective, we did not consider it necessary to statistically process the result of this parameter; we believe that the difference of 4.482 points between the averages of the two tests allows us to assert that the therapeutic intervention has met the objective regarding the discomfort of the subjects. With all these limitations, the decrease in the intensity of pain for the study participants confirms that the therapeutic intervention has reached the estimated results.

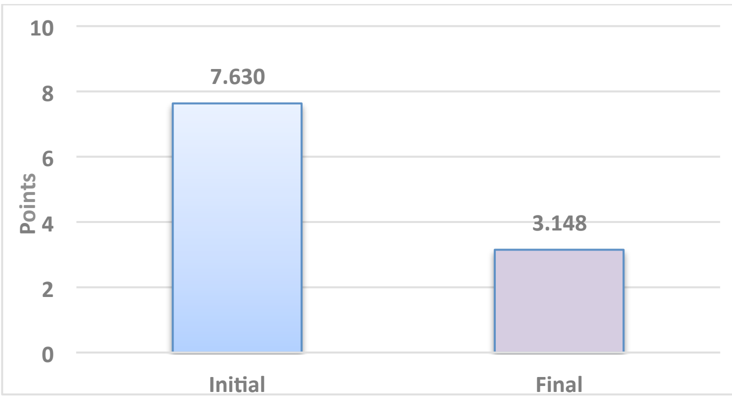

Figure 02. Pain – Averages of the initial and final tests

As for the assessment of the anterior left, right and posterior left, right plantar support areas, it is obvious that this parameter has undergone changes in all four components between the two tests (Figure 03), which is also revealed in Table 01 that shows the difference between the averages of the two tests.

Table 01. Plantar support area (cm^2) – Averages of the initial and final tests

Testing	Anterior left	Anterior right	Posterior left	Posterior right
Initial	41.925	43.407	40.555	42.222
Final	44.370	43.851	44.037	43.629
T	0.043	0.383	0.004	0.126

The results of the statistical processing of data from the two tests are summarised in Table 01, where significant statistical differences are emphasised for the components of the anterior left

(0.043<0.05) and posterior left (0.004<0.05) plantar support area. For the components of the anterior right (0.383>0.05) and posterior right (0.126>0.05) plantar support area, the statistical processing does not reveal significant statistical differences.

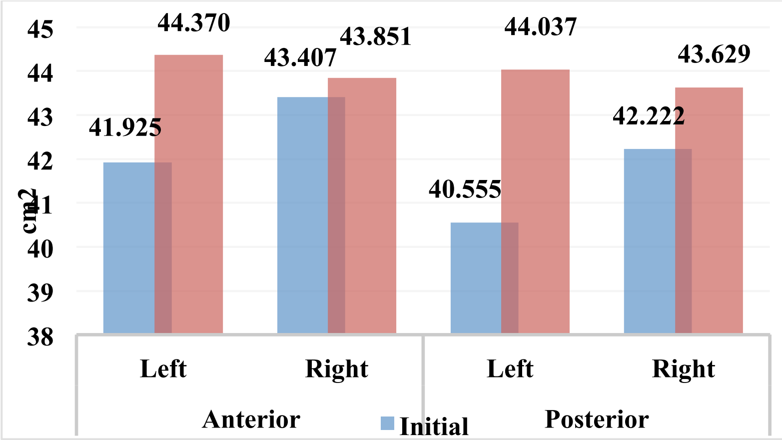

Figure 03. Plantar support area (cm^2) – Averages

Table 02 summarises the data concerning the total averages for the left and right plantar support areas. The statistical data processing underlines statistical differences for the left plantar support area (0.006<0.05), while for the right plantar support area, the differences are not statistically significant (0.180>0.05).

Table 02. Plantar support area (cm^2) – Total

Testing	Total left	Total right
Initial	82.481	85.629
Final	88.407	87.481
t	0.006	0.180

The graphical representation in Figure 04 highlights the changes in both the left (5.926 cm^2) and right (1.852 cm^2) areas. We believe that these differences are acceptable, considering that, first of all, the study subjects show a predominance of the right hemisphere, and secondly, the study purpose is to reveal the presence of certain foot posture modifications, and not to interpret these modifications.

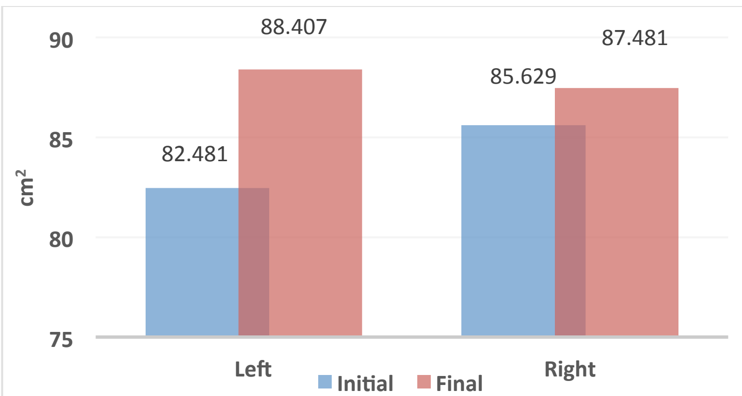

Figure 04. Plantar support area (cm^2) – Total - left, right

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The study results confirmed the existence of differences between the two tests and, even if a part was not statistically confirmed, we aimed to observe the presence of certain changes in the initial posture of the foot, as a result of the therapeutic intervention performed in this study. Considering the limitations of this study, we mention that the achieved results were not compared to reference data regarding the foot posture, an issue that will be a challenge for a future study.

7. Conclusion

Early detection of the foot posture modifications allows performing a corrective treatment at the right time and, where appropriate, the family physician must identify, properly classify these problems and detect the cases that go beyond the “physiological” area and require orthopedic examination.

We believe that, to settle certain problems regarding the health preservation and strengthening in the musculoskeletal system, it is necessary to know and consider the biological modifications occurring inside the body during the growth and development period.

The study results confirm that a therapeutic intervention based on a precise functional diagnosis can induce modifications of the foot posture, in the sense that these modifications reduce the subjects' pain and discomfort, ensuring an improvement in their quality of life.

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